Pages 5111–5158

PART II

FEDERAL REGISTER

VOLUME 29 NUMBER 73

Washington, Tuesday, April 14, 1964

Federal Aviation Agency

Proposed Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes

Proposed Rule Making

FEDERAL AVIATION AGENCY

[14 CFR Parts 3, 23 [New]]

[Reg. Docket No. 4080; Notice 64–17]

AIRWORTHINESS STANDARDS: NORMAL, UTILITY, AND ACROBATIC CATEGORY AIRPLANES

Notice of Proposed Rule Making

The Federal Aviation Agency is considering a proposal to recodify present Part 3 of the Civil Air Regulations into Part 23 [New].

Interested persons are invited to participate in the proposed recodification by submitting such written data, views, or arguments as they may desire. Communications should identify the regulatory docket or notice number and be submitted in duplicate to the Federal Aviation Agency, Office of the General Counsel: Attention Rules Docket, 800 Independence Avenue SW., Washington, D.C., 20533. All communications received within 60 days after publication of this notice in the FEDERAL REGISTER will be considered by the Administrator before taking action on the proposed recodification. The proposal contained in this notice may be changed in the light of comments received. All comments submitted will be available, both before and after the closing date for comments, in the Rules Docket for examination by interested persons.

The object of Part 23 [New] is to restate existing regulations, not to make new ones. The pertinent provisions have been freely reworded and re-arranged, subject to every precaution against disturbing existing rights, privileges, duties, or functions. In addition, in cases where well established administrative practice or construction has established authoritative interpretations, the revised language reflects the interpretations.

Each proposed recodified section is followed by a note citing the present section of the regulations upon which it is based. A cross-reference table has been placed at the end of Part 23 [New] to permit easy access from the old regulations to the new. Internal cross references to parts or sections that are not yet recodified contain a blank space for later insertion of the correct recodified number with the present number contained in brackets. When a part or section that is referred to in a cross reference is later recodified, the correct number will be inserted and the bracketed number will be dropped.

No substantive changes involving an increased burden on the public have been made in the regulations, the purpose of the recodification project being simply to streamline and clarify present regulatory language and to delete obsolete or redundant provisions. It should be noted that the definitions, abbreviations, and rules of construction contained in Part 1 [New] published in the FEDERAL REGISTER on May 15, 1962 (27 F.R. 4587), would apply to the proposed rules. In addition, those definitions in present Part 3 (and not now in Part 1 [New] or executed in proposed Part 23 [New]) that are necessary, will be recodified with the definition of the other airworthiness parts and added to Part 1 [New] prior to the adoption of Part 23 [New].

Proposed Part 21 [New] will contain the procedural requirements for type certification. These requirements, though basically identical, are now repeated in 10 separate airworthiness parts. Proposed Part 23 [New] contains the airworthiness requirements for airplanes to be certificated in the normal, utility, or acrobatic categories.

Proposed FAR § 23.21 [New] requires that all flight requirements be met at the critical combination of airplane weight and center of gravity within the range of loading conditions for which certification (in accordance with proposed Part 21 [New]) is requested. As this general rule applies to all flight tests, it has not been repeated in each test requirement.

Present CAR § 3.109(a)(2) requires that during the demonstration of longitudinal control, it must be possible at all speeds below the best angle of climb speed V_X to pitch the nose downward so that the rate of increase in airspeed is enough for prompt acceleration to V_X with power off and the airplane trimmed at 1.5 V_{S_1} or at the minimum trim speed, whichever is higher. As this is unnecessary to demonstrate longitudinal control, this requirement has been changed to permit the use of the trim speed instead of V_X. In addition, the trim requirements of § 3.112(b) require that a multiengine airplane maintain longitudinal and directional trim . . . "during climbing flight" with the critical engine inoperative and with certain other requirements. This has been changed by deleting the requirement that the airplane be in climbing flight in this demonstration as safe trim characteristics may be demonstrated without such climbing flight.

Present CAR 3 Appendix A, "Simplified Design Load Criteria for Airplanes Having a Design Weight Equal to or Less Than 6,000 Pounds", has been recodified and is Appendix A of proposed Part 23. The figures following CAR § 3.211, containing acceptable values of control surface loadings, have been consolidated and placed in Appendix B of this proposed part. Similarly, the material containing acceptable landing conditions, and the material containing an acceptable method to determine wheel spin-up loads, has been placed in Appendices C and D, respectively, of the proposed part.

When finally adopted, Part 23 [New] will include the substance of any applicable rules or amendments adopted and made effective during the period between the date of notice and the effective date of the final rule, and may also include applicable rules on which individual notices of proposed rule making have been issued and the comment period has expired, but which have not been theretofore adopted.

In consideration of the foregoing it is proposed to amend Chapter I of Title 14 of the Code of Federal Regulations by deleting Part 3 and adding a Part 23 [New] reading as hereinafter set forth.

This proposal is made under the authority of §§ 313(a), 601, and 603 of the Federal Aviation Act of 1958 (72 Stat. 752, 775, 776; 49 U.S.C. 1354(a), 1421, and 1423).

Issued in Washington, D.C., on March 25, 1964.

N. E. HALABY,
Administrator.

DISTRIBUTION TABLE

Old section	*New section*
3.0	23.1
3.1	(1)
3.10–3.19	(2)
3.20 (less 2d sentence of (a)(2) and 2d and 3d sentences of (b))	23.3
3.20(a)(2) (2d sentence)	(3)
3.20(b) (2d and 3d sentences)	(4)
3.20–1	23.3
3.20–2 (1st sentence)	23.3
3.20–2 (less 1st sentence)	(5)
3.61	23.21
3.62–3.65	(3)
3.71	23.31
3.71–1	(5)
3.72	23.33
3.72–1	(5)
3.73 (1st sentence)	23.31
3.73 (2d sentence)	23.31
3.73–1	(3)
3.73–2	(5)
3.73–3 (less (b))	(5)
3.73–3(b)	23.31
3.74	23.35
3.75	23.37
3.76	23.39
3.76–1	(5)
3.80	(6)
3.81	23.49
3.82	23.51
3.82–1	23.51
3.83	23.51
3.84	23.61
3.84–1	(5)
3.84–2	23.61
3.84–3	(5)
3.84a	23.63
3.85	23.73
3.85–1	(5)
3.85–2	(4)
3.85–3	23.73
3.85–4 (last sentence)	23.371
3.85–4 (less last sentence)	(3)
3.85–5(a)	(3)
3.85(b) (less (1) and (2))	23.73
3.85–5(b)(1) and (2)	(7)
3.85a	23.75
3.86	23.85
3.86–1	23.85
3.86–2	(5)
3.87	23.87
3.105	23.97
3.106	23.107
3.107	23.109

See footnotes at end of table.

DISTRIBUTION TABLE—Continued

Old section	New section
3.108	23.111
3.109	23.113
3.110	23.115
3.111	23.117
3.112	23.127
3.113	23.137
3.114	23.139
3.115	23.139
3.116	23.141
3.117	23.143
3.118	23.145
3.118–2	(5)
3.120	23.155
3.120–1 (1st sentence)	(3)
3.120–1 (less 1st sentence)	23.155
3.120–2	(5)
3.121	23.157
3.121–1	(5)
3.122	23.159
3.123	23.161
3.124	23.171
3.143	(6)
3.144	23.181
3.145	23.183
3.146	23.185
3.147	23.187
3.159	23.197
3.171	23.217
3.171–1	(5)
3.171–2	(5)
3.172	23.219
3.173	23.221
3.173–1	(5)
3.174	23.223
3.174–1 through 8	(6)
3.181	23.233
3.182	23.233
3.183	23.243
Figure 3–1	23.243
3.184	23.245
3.185	23.247
3.186	23.249
3.187	23.251
3.188	23.253
3.188–1	23.253
3.189	23.255
3.190	23.265
Note following 3.190	23.265
3.190–1	23.265
3.191 and note	23.275
3.191–1	(5)
3.194	23.285
Note following 3.194	23.285
3.195	23.287
3.196	23.289
3.197	23.291
3.211	23.301
Note following 3.211 (including figures 3–3 (a) and (b), and figures 3–4, 3–5(a), 3–5(b), 3–6, 3–7, 3–8, 3–9, 3–10)	(9)
3.211–1	(5)
3.212	23.303
Figure 3–11	23.303
3.212–1	23.303
3.213	23.305
3.214	(6)
3.215 and note	23.315
3.216 and notes	23.317
3.216–1 (including figure 1)	(5)
3.216–2	(5)
3.216–3	(5)
3.216–4 (a) and (b)	23.317
3.216–4 (less (a) and (b))	(5)
3.216–5	(5)
3.216–6	(5)
3.217 (intro. para. and (a))	23.319
3.217 (b) and (c) and note	23.319
3.217–1	(5)
3.218	23.321
3.219 and notes	23.331
3.219–1	(5)
3.220	23.333
3.220–1	(5)
3.221	23.335
3.222 (less (c) and (d))	23.345
3.222 (c) and (d)	(7)

See footnotes at end of table.

DISTRIBUTION TABLE—Continued

Old section	New section
3.223	23.347
3.223–1	(5)
3.224	23.349
3.224–1	(5)
3.225	23.351
3.231	23.357
3.231–1 (1st and 4th sentences)	23.357(b)
3.231–1 (less 1st and 4th sentences)	(5)
3.231–2	23.357
3.231–3	(5)
3.232	23.359
3.233	23.361
3.233–1	23.361
3.234	23.363
3.241	23.369
3.241–1	(5)
3.241–2	(5)
3.242	23.371
3.243	23.373
3.244	23.383
Fig. 3–12(a)	(10)
3.244–1	(5)
3.245	23.385
3.245–1(a)	(3)
3.245–1(b) (before equation)	23.385
3.245–1(b) (equation and following)	(11)
3.245–1(c)	(5)
3.245–2	(5)
Fig. 3–12(b)	(10)
3.246	23.387
3.247	23.389
3.248	23.399
3.249	23.401
3.250	23.411
3.251	23.411
3.252	23.411
3.253	23.421
3.254	23.421
3.255	23.421
3.256	23.421
3.257	23.431
3.257–1	(3)
3.257–2	(5)
3.257–3	(5)
3.265	23.441
3.265–1(a)	23.441
3.265–1(b)	(5)
3.265–2	23.441
3.270	23.451
3.291	23.471
3.292	23.473
3.293	23.475
3.294	23.477
3.295	23.479
3.296	23.481
3.301 and note following	23.491
3.301–1 (less 1st sentence of (b))	23.493
3.301–1 (1st sentence of (b))	(5)
3.201–2	23.495
3.302	23.497
3.303	23.499
3.304	23.501
3.305	23.503
3.306	23.505
3.307	23.507
3.311	23.525
3.311–1	(5)
Discussion of policies (following 3.311–1)	(5)
3.311–2 (less (a))	(5)
3.311–2(a)	23.525
3.317	23.535
3.318	23.537
3.327	23.547
3.328	23.549
3.328–1	(5)
3.329	23.551
3.330	23.553
3.335	23.563
3.336	23.565
3.336–1	(5)
3.337	23.567
3.337–1 through 3	(7)
3.338	23.569
3.338–1	23.571
3.339	23.573
3.340	23.575
3.341	23.577

DISTRIBUTION TABLE—Continued

Old section	New section
3.342	23.579
3.343	23.581
3.344	23.591
3.345	23.593
3.345–1	23.593
3.345–2	(5)
3.345–3	(5)
3.346	23.595
3.347	23.597
3.351	23.607
3.352	23.609
3.352–1	(5)
3.353	23.611
3.354	23.613
3.355	23.615
3.356	23.625
3.356 (less last sentence of (b))	(5)
3.356 (less last sentence of (b))	23.625
3.357	23.627
3.358	23.629
3.359	23.631
Note following 3.359 (less last sentence)	(5)
Note following 3.359 (last sentence)	23.631
3.360	(3)
3.361	23.643
3.362	23.645
3.362–1	23.645
3.362–2	(5)
3.363	23.655
3.364	23.665
3.364–1	(5)
3.371	23.675
3.372	23.677
3.373	23.679
3.381	23.689
3.382	23.693
3.382–1	(5)
3.382–2	(5)
3.383 (incl. note following (b))	23.695
Note following 3.383(d)	(5)
3.383–1	(5)
3.384	23.697
Figure 3–13	23.697
Figure 3–14	23.697
3.385	23.699
3.386	23.709
3.386–1	(5)
3.387	23.711
3.388	23.713
3.388–1 through 3	(5)
3.388–4	(3)
3.389	23.723
3.390	23.725
3.390–1 (intro. para.)	23.725
3.390–2	(5)
3.390–3	(5)
3.392	23.727
3.392–1	(5)
3.393	23.729
3.394 (less parentheses)	(6)
3.394 (parentheses)	(12)
3.395	23.739
3.396	23.741
3.401	23.751
3.411	23.771
3.411–1	23.771
3.415	23.781
3.416	23.783
3.417	23.785
3.418	23.787
3.419	23.789
3.419–1(a) (2d sentence)	23.789
3.419–1(a) (less 2d sentence)	(13)
3.419–1(b) (1st sentence)	23.789
3.419–1(b) (less 1st sentence)	(3)
3.419–1(c)	(5)
3.420	23.791
3.421	23.793
3.422	23.795
3.422–1	(5)
3.422–2 (1st sentence)	23.795
3.422–2 (less 1st sentence)	(5)
3.429	23.805
3.430	23.807
3.431	23.809
3.431–1	(5)
3.433	23.819
3.434	23.821

DISTRIBUTION TABLE—Continued

Old section	New section
3.435	23.823
3.436	23.825
3.437	23.827
3.438	23.829
3.439	23.831
3.440	23.841
3.441	23.843
3.442	23.845
3.442–1	23.845
3.443	23.847
3.444	23.849
3.445	23.851
3.446	23.853
3.447–A	23.855
3.448	23.857
3.449	23.867
3.449–1	23.867
3.550	23.877
3.551	23.879
3.552	23.881
3.553	23.891
3.554	(3)
3.561	23.903
3.561–1(a)	(5)
3.561–1(b)	23.903
3.562	(3)
3.563	23.915
3.564	23.917
3.565	23.919
3.566	23.921
3.567	23.923
3.568	23.925
3.569	23.927
3.570	23.937
3.571	(3)
3.572	23.941
3.573	23.943
3.574	23.945
3.575	23.947
3.576	(3)
3.577	23.951
3.581	23.961
3.582 (less last sentence)	23.971
3.582 (last sentence)	(4)
3.582–1	23.971
3.583	23.973
3.583–1 (1st sentence)	23.973
3.583–1 (less 1st sentence)	(5)
3.584	23.973
3.585	23.973
3.586	23.975
3.587	23.977
3.587–1	(5)
3.588	23.985
3.589	23.987
3.590	23.989
3.591	23.991
3.592	23.993
3.593	23.995
3.594	23.997
3.595	23.999
3.596	(3)
3.605	23.1011
3.606	23.1013
3.606–1	(5)
3.607	23.1015
3.608	23.1017
3.609	23.1019
3.610	23.1021
3.611	23.1023
3.612	23.1025
3.615	23.1035
3.616	23.1037
3.617	23.1039
3.618	23.1041
3.623	23.1051
3.623–1	23.1055
3.624	23.1055
3.625	23.1057
3.627	23.1067
3.628	23.1069
3.629	23.1071
3.630	23.1073
3.631	23.1075
3.632	23.1077
3.633	23.1079
3.634	23.1081
3.635	23.1091

See footnotes at end of table.

DISTRIBUTION TABLE—Continued

Old section	New section
3.636	23.1093
3.637	23.1103
3.638	23.1105
3.651	23.1125
3.652	23.1127
3.652–1	23.1127
3.655	23.1129
3.661	23.1139
3.662	23.1141
3.663	23.1151
3.664	23.1153
3.665	23.1155
3.666	23.1157
3.667	23.1159
3.668	23.1161
3.669	23.1163
3.670	23.1173
3.671	23.1175
3.672	23.1177
3.672–1	23.1177
3.673	23.1179
3.674	23.1181
3.675	23.1183
3.681	23.1193
3.682	23.1203
3.683	23.1205
3.685	23.1207
3.686	23.1209
3.687 and note	23.1219
3.688	23.1221
3.689	23.1223
3.690	23.1233
3.691	23.1235
3.692	23.1237
3.693	23.1247
3.694	23.1249
3.695	23.1251
3.696	23.1261
3.696–1	23.1261
3.697	23.1263
3.698	23.1273
3.699	23.1275
3.700	23.1285
3.700–1	(5)
3.701	23.1287
3.702	23.1289
Figure 3–15	23.1291
Figure 3–16	23.1293
Figure 3–17	23.1295
3.702–1	23.1289
3.702–2	23.1289
3.703	23.1297
3.704	23.1305
3.705	23.1315
Figure 3–18	23.1315
3.705–1 (1st sentence)	23.1315
3.705–1 (less 1st sentence)	23.1317
3.711	23.1327
3.712	23.1329
3.713	(4)
3.714	(4)
3.715	23.1335
3.716	23.1345
3.716–1	(3)
3.717	23.1347
3.718	23.1349
3.721	23.1359
3.721–1	(5)
3.721–2	(5)
3.725	23.1369
3.726	23.1379
3.727	23.1381
3.728	23.1383
3.735	23.1403
3.737	23.1413
3.738	23.1423
3.739	23.1423
3.740	23.1423
3.741	23.1423
3.742	23.1423
3.743	23.1423
3.744	23.1433
3.748	23.1443
3.749	23.1453
3.750	23.1463
3.755	23.1473
3.755–1	(5)
3.755–2	(5)
3.756	23.1483

DISTRIBUTION TABLE—Continued

Old section	New section
3.757	23.1485
3.757–1	(5)
3.758	23.1487
3.759	23.1489
3.759–1	(5)
3.760	23.1491
3.761	23.1493
3.762	23.1503
3.762–1	23.1503
3.763	23.1505
3.764	23.1507
3.765	23.1509
3.766	23.1519
3.767	23.1521
3.768	23.1523
3.769	23.1525
3.770	23.1527
3.771	23.1529
3.772	23.1531
3.777	23.1541
3.777–1	(5)
3.777–2 through 4	(3)
3.778	23.1543
3.779	23.1545
3.780	(14)
3.780–2	(5)
3.780–3(a) (1st sentence)	23.1547
3.780–3(a) (less 1st sentence)	(5)
3.780–3(b) (1st sentence)	23.1547
3.780–3(b) (less 1st sentence)	(5)
3.791–3.792	(15)

APPENDIX A

Old section	New section
1.0	23.217
1.1 (less last sentence)	A23.1
1.1 (last sentence)	(5)
1.2 (1st and 2d sentences)	23.217
1.2 (less 1st and 2d sentences)	(5)
2.1	(5)
2.2	(5)
2.30	(5)
2.31	(5)
2.32	(5)
2.33	(5)
2.4	(5)
3.1 (intro. para.)	A23.1
3.1 (less intro. para.)	A23.3
4.0	A23.5
5.1 (1st sentence)	A23.7
5.1 (2d sentence)	A23.7
5.10	A23.7
5.11	A23.7
5.12	A23.7
5.2 (less 3d sentence)	A23.7
5.2 (3d sentence)	(3)
5.3	A23.7
5.4	A23.7
6.1	A23.9
6.20	A23.9
6.201	A23.9
6.202	A23.9
6.203	A23.9
6.21	A23.9
6.3	A23.9
6.30	A23.9
6.31	A23.9
6.32 (1st and 2d sentences)	A23.9
6.32 (3d sentence to end)	A23.9
6.4	A23.9
6.40	A23.9
6.41	A23.9
6.42	A23.9
7.1	A23.11
7.2	A23.11
7.30	A23.11
7.31	A23.11
7.4	A23.11
7.5	A23.11
8.10	A23.13
8.101	A23.13
8.102	A23.13
8.11	A23.13
8.2	A23.13
8.3	A23.13
8.4	A23.13
Figure 4	(16)
Figure 5	(16)
Table 1	(16)

APPENDIX A—Continued

Old section	New section
Table 2	(16)
Figure 6	(16)
Figure 7	(16)
Figure 8	(16)
Figure 9	(16)
Appendix B	(17)
Appendix C	(17)
Appendix D:	
SR-392D	(18)
SR-425C	(2)

[1] Executed or transferred to Part 1 [New].
[2] Transferred to proposed Part 21.
[3] Surplusage.
[4] Obsolete.
[5] Not a rule.
[6] Executed.
[7] Not rules.
[8] Surplusage or not rules.
[9] Appendix B.
[10] Appendix C.
[11] Appendix D.
[12] Precedes 23.739.
[13] Surplusage or not a rule.
[14] 23.1547 (less (d)).
[15] Transferred to proposed Part 45.
[16] (Follow A23.13).
[17] Nonregulatory.
[18] Leave as is.

PART 23—AIRWORTHINESS STANDARDS: NORMAL, UTILITY, AND ACROBATIC CATEGORY AIRPLANES

Subpart A—General

Sec.
23.1 Applicability.
23.3 Airplane categories.

Subpart B—Flight Requirements

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AUTHORITY: The provision of this Part 23 issued under 72 Stat. 752, 775, 776; 49 U.S.C. 1354(a), 1421, and 1423.

Subpart A—General

§ 23.1 Applicability.

This part prescribes airworthiness requirements for issuing type certificates and changes to those certificates, for small airplanes. Each person who applies under Part 21 [New] for a type certificate or a change to a type certificate must show that the airplane concerned meets the applicable requirements of this part.

[Revision note: based on § 3.0]

§ 23.3 Airplane categories.

(a) The Administrator designates the following airplane categories:

(1) Normal category, for each airplane intended for nonacrobatic operation. Nonacrobatic operation includes all maneuvers incident to normal flying, stalls (except whip stalls), and turns in which the angle of bank is not great than 60 degrees.

(2) Utility category, for each airplane intended for limited acrobatic operation. Limited acrobatic operation includes all maneuvers incident to normal flying, stalls (except whip stalls), spins (if approved for the particular type of aircraft), lazy eights, chandelles, and steep turns in which the angle of bank is greater than 60 degrees.

(3) Acrobatic category, for each airplane intended for use without restrictions other than those shown to be necessary as a result of required flight tests.

(b) The Administrator may certificate an airplane under the requirements of a single category, or in more than one category, if all the requirements of each desired category are met.

[Revision note: Combines §§ 3.20 (less 2d sentence of (a)(2), (b) (2d and 3d sentences)), 3.20–1, and 3.20–2 (1st sentence)]

Subpart B—Flight Requirements

GENERAL

§ 23.21 Proof of compliance.

(a) Each applicant must show, by flight or other tests (or by calculations based upon tests if calculated results are substantially equal in accuracy to results obtainable by direct testing), that the airplane meets the requirements of this subpart.

(b) The airplane must meet the requirements of this subpart at the critical combination of airplane weight and center of gravity within the range of loading conditions for which certification is requested. This requires a systematic investigation of all probable weight and center of gravity combinations unless compliance is reasonably inferable from those actually investigated.

[Revision note: Based on § 3.61]

WEIGHT RANGE AND CENTER OF GRAVITY

§ 23.31 Weight and balance.

(a) Each applicant must establish ranges of weights and centers of gravity within which the airplane may be safely operated. If low fuel adversely affects balance or stability, the airplane must be tested under conditions simulating those that would exist when the amount of usable fuel on board does not exceed one gallon for each 12 maximum continuous horsepower of the engine or engines.

(b) The empty weight (and the corresponding center of gravity) includes all—

(1) Fixed ballast;

(2) Unusable fuel;

(3) Undrainable oil (all oil remaining in the airplane while in the ground attitude after drainage from all oil drains);

(4) Engine coolant; and

(5) Hydraulic fluid.

(c) The weight and the location of each item of equipment that is installed when the airplane is weighed must be recorded in the airplane flight manual.

[Revision note: Combines §§ 3.71, 3.73, and 3.73–3(b)]

§ 23.33 Use of ballast.

Removable ballast may be used in the airplane to comply with the flight requirements of this part, if—

(a) The place for carrying ballast is properly designed and installed, and is marked in accordance with § 23.1519; and

(b) The airplane flight manual includes instructions for the proper placement of the removable ballast under all

loading conditions for which removable ballast is necessary.

[Revision note: Based on § 3.72]

§ 23.35 Maximum certificated weight.

(a) The maximum certificated weight for airplanes may not exceed—

(1) The selected weight;

(2) The proven design weight (except as provided in § 23.371 for multiengine airplanes); or

(3) The maximum weight at which compliance with all of the applicable flight requirements of this part is demonstrated.

(b) Assuming a weight of 170 pounds for each occupant of each seat for normal category airplanes, and 190 pounds for utility and acrobatic category airplanes (except if otherwise placarded), the maximum certificated weight for any airplane may not be less than its weight with—

(1) All seats occupied, oil to full tank capacity, and at least enough fuel for one-half hour of operation at rated maximum continuous power; or

(2) The required minimum crew, and fuel and oil to full tank capacity.

[Revision note: Based on § 3.74]

§ 23.37 Minimum certificated weight.

The minimum certificated weight for airplanes may not exceed the sum of—

(a) The empty weight of the airplane as defined in § 23.31(b);

(b) The total weight of the required minimum crew (assuming a weight of 170 pounds for each crewmember);

(c) The weight of the oil at full tank capacity; and

(d) The weight of no more than the quantity of fuel required for one-half hour of operation at rated maximum continuous power.

[Revision note: Based on § 3.75]

§ 23.39 Recording of loading instructions in the airplane flight manual.

Loading instructions must be recorded in the airplane flight manual if the center of gravity under any possible loading condition between the maximum certificated weight (determined in accordance with § 23.35) and the minimum certificated weight (determined in accordance with § 23.37) is outside of—

(a) The extremes selected by the applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with all functional requirements is demonstrated.

[Revision note: Based on § 3.76]

Performance Requirements

GENERAL

§ 23.49 Performance.

Each applicant must show that the airplane meets the performance requirements of this part (corrected for standard atmosphere and still air).

[Revision note: Based on § 3.81]

§ 23.51 Stalling speed.

(a) V_{S_0} is the stalling speed, if obtainable, or the minimum steady speed at which the airplane is controllable (expressed in miles per hour calibrated airspeed), with—

(1) Engine(s) idling, throttle(s) closed (or at not more than sufficient power for zero thrust at 110 percent of the stalling speed);

(2) Propeller(s) in the takeoff position;

(3) Landing gear extended;

(4) Wing flaps in the landing position;

(5) Cowl flaps closed;

(6) The center of gravity in the most unfavorable position within the allowable landing range; and

(7) The weight of the airplane equal to the weight in connection with which V_{S_0} is being used to determine compliance with a required performance standard.

(b) V_{S_0} at maximum certificated weight may not exceed 70 miles per hour for—

(1) Single engine airplanes; and

(2) Multiengine airplanes that cannot meet the minimum rate of climb specified in § 23.75(b) with the critical engine inoperative.

(c) V_{S_1} is the stalling speed, if obtainable, or the minimum steady speed at which the airplane is controllable (expressed in miles per hour calibrated airspeed), with—

(1) Engine(s) idling, throttle(s) closed (or at not more than sufficient power for zero thrust at 110 percent of the stalling speed);

(2) Propeller(s) in the takeoff position;

(3) All systems (such as flaps and landing gear) in the particular condition existing in the particular test in connection with which V_{S_1} is being used; and

(4) The weight of the airplane equal to the weight in connection with which V_{S_1} is being used as a factor to determine compliance with a required performance standard.

(d) V_{S_0} and V_{S_1} must be determined by flight tests, using the procedure specified in § 23.155.

[Revision note: Combines §§ 3.82, 3.82–1, and 3.83]

TAKEOFF

§ 23.61 Takeoff requirements for airplanes of more than 6,000 pounds maximum weight.

(a) The distance required to take off and climb over a 50-foot obstacle must be determined with—

(1) The engine(s) operating within approved limitations; and

(2) The cowl flaps in the position normally used for takeoff.

Upon reaching a height of 50 feet above the takeoff surface level, the airplane must have attained a speed of not less than 1.3 V_{S_1} unless a lower speed of not less than V_X plus 5 can be shown to be safe under all conditions, including turbulence and complete engine failure.

(b) The starting point for measuring seaplane takeoff distances may be the point at which it has attained a speed of not more than three miles per hour.

(c) The takeoff within the distance determined in accordance with paragraph (a) of this section may not require exceptional piloting skill or exceptionally favorable conditions.

(d) The distance obtained in accordance with paragraph (a) of this section, the type of surface from which the takeoff was made, and the pertinent information with respect to cowl flap position, use of flight-path control devices, and use of the landing gear retraction system, must be recorded in the airplane flight manual.

[Revision note: Combines §§ 3.84 and 3.84–2]

§ 23.63 Takeoff requirements for airplanes of 6,000 pounds or less maximum weight.

(a) Safe takeoff may not require exceptional piloting skill.

(b) The airplane, with takeoff power applied, must have sufficient elevator control—

(1) For a tail-wheel type airplane, to maintain, at a speed equal to 0.8 V_{S_1}, an attitude that will allow holding the airplane on the runway until a safe takeoff speed is attained; and

(2) For a nose-wheel type airplane to raise the nose-wheel clear of the takeoff surface at a speed equal to 0.85 V_{S_1}.

[Revision note: Based on § 3.84a]

CLIMB

§ 23.73 Climb requirements for airplanes of more than 6,000 pounds maximum weight.

(a) The airplane must have a steady rate of climb at sea level of at least 300 feet per minute and a steady angle of climb of at least 1:12 for land planes or 1:15 for seaplanes with—

(1) Not more than maximum continuous power on each engine;

(2) The landing gear retracted;

(3) The wing flaps in the takeoff position; and

(4) The cowl flaps in the position used in the cooling tests required by §§ 23.961 through 23.999.

(b) For an airplane with an engine or engines for which the takeoff and maximum continuous power ratings are identical and that has fixed-pitch, two-position, or similar propellers, a lower propeller pitch setting than that permitted by § 23.789 may be used to obtain rated engine r.p.m. at the best angle-of-climb speed if—

(1) The airplane shows marginal performance (such as when it can meet the rate of climb requirements of paragraph (a) of this section but has difficulty in meeting the angle of climb requirements of paragraph (a) or (d)); and

(2) Acceptable engine cooling is shown at the lower speed associated with the best angle of climb.

(c) A multiengine airplane must be able to maintain a steady rate of climb of at least 0.02 $V_{S_0}^2$ (in feet per minute) at an altitude of 5,000 feet with—

(1) The critical engine inoperative;

(2) The remaining engine(s) operating at not more than maximum continuous power;

(3) The inoperative propeller in the minimum drag position;

(4) The landing gear retracted;
(5) The wing flaps in the most favorable position; and
(6) The cowl flaps in the position used in the cooling tests required by §§ 23.961 through 23.999.

(d) For a balked landing, the airplane must be able to maintain a steady angle of climb at sea level of at least 1: 30 with—
(1) Takeoff power on all engines;
(2) The landing gear extended; and
(3) The wing flaps in landing position, except that, if the flaps may safely be retracted in two seconds or less without loss of altitude and without requiring sudden changes of angle of attack or an exceptional degree of piloting skill, they may be retracted.

[Revision note: Combines §§ 3.85, 3.85–3, and 3.85–5(b) (less (1) and (2))]

§ 23.75 Climb requirements for airplanes of 6,000 pounds or less maximum weight.

(a) The airplane must have a steady rate of climb at sea level of 300 feet per minute, or 10 times V_{S_1} (expressed in feet per minute), whichever is greater, with—
(1) Takeoff power applied;
(2) The landing gear extended;
(3) The wing flaps in the takeoff position; and
(4) The cowl flaps in the position used in the cooling tests required by §§ 23.961 through 23.999.

(b) A multiengine airplane with a stalling speed V_{S_0} of more than 70 miles per hour must be able to maintain a steady rate of climb of at least $0.02\ V_{S_0}^2$ (in feet per minute), at an altitude of 5,000 feet with—
(1) The critical engine inoperative;
(2) The remaining engine(s) operating at not more than maximum continuous power;
(3) The inoperative propeller in the minimum drag position;
(4) The landing gear retracted;
(5) The wing flaps in the most favorable position; and
(6) The cowl flaps in the position used in the cooling tests required by §§ 23.961 through 23.999.

(c) The steady rate of climb at 5,000 feet for a multiengine airplane with a stalling speed of 70 miles per hour or less must be determined with—
(1) The critical engine inoperative;
(2) The remaining engine(s) operating at not more than maximum continuous power;
(3) The inoperative propeller in the minimum drag position;
(4) The landing gear retracted;
(5) The wing flaps in the most favorable position; and
(6) The cowl flaps in the position used in the cooling tests required by §§ 23.961 through 23.999.

(d) For a balked landing, the airplane must be able to maintain a steady rate of climb at sea level of 200 feet per minute, or five times V_{S_0} (in feet per minute), whichever is greater, with—
(1) Takeoff power on each engine;
(2) The landing gear extended; and
(3) The wing flaps in the landing position, except that, if rapid retraction is possible with safety, without loss of altitude, and without requiring sudden changes of angle of attack or an exceptional degree of piloting skill, they may be retracted.

[Revision note: Based on § 3.85a]

LANDING

§ 23.85 Landing requirements for airplanes of more than 6,000 pounds maximum weight.

(a) The horizontal distance required to land and come to a complete stop (or to a speed of approximately three miles per hour for seaplanes or floatplanes) from a point at a height of 50 feet above the landing surface must be determined. Immediately before reaching this point, the airplane must be maintained in a steady gliding approach with a calibrated airspeed of at least $1.5\ V_{S_1}$.

(b) The landing within the distance determined in accordance with paragraph (a) of this section may not require exceptional piloting skill or exceptionally favorable conditions. The airplane must be able to be landed without excessive vertical acceleration, and without tending to bounce, nose over, ground loop, porpoise or water loop.

(c) The distance obtained in accordance with paragraph (a) of this section, the kind of surface on which the landing was made, and the pertinent information with respect to flap position and the use of flight-path control devices must be in the airplane flight manual.

(d) Unless approved by the Administrator, reverse thrust may not be used in the determination of the horizontal distance required to land and come to a complete stop.

[Revision note: Combines §§ 3.86 and 3.86–1]

§ 23.87 Landing requirements for airplanes of 6,000 pounds or less maximum weight.

The airplane must be able to be landed safely and come to a stop without exceptional piloting skill and without excessive vertical acceleration, tendency to bounce, nose over, ground loop, porpoise, or water loop.

[Revision note: Based on § 3.87]

FLIGHT CHARACTERISTICS

§ 23.97 Flight characteristic requirements.

Each applicant must show that the airplane meets the requirements of §§ 23.107 through 23.171 at all normally expected operating altitudes, under all critical loading conditions within the center of gravity range and, unless otherwise specified, at the maximum weight for which certification is requested.

[Revision note: Based on § 3.105]

CONTROLLABILITY

§ 23.107 General.

(a) The airplane must be satisfactorily controllable and maneuverable during takeoff, climb, level flight, dive, and landing with or without power. It must be possilbe to make a smooth transition from one flight condition to another (including turns and slips) without an exceptional degree of skill, alertness or strength on the part of the pilot, and without danger of exceeding the limit load factor, under all conditions of operation probable for the type (including, for multiengine airplanes, those conditions normally encountered in the event of sudden failure of any engine).

(b) If, during the testing required by paragraph (a) of this section, the Administrator finds that marginal conditions exist with regard to the strength required of the pilot, quantitative testing must show that the "strength of pilots" limits do not exceed the limits prescribed in the following table:

Values in pounds of pressure	Pitch	Roll	Yaw
(a) For temporary application:			
Stick	60	30	150
Wheel (applied to rim)	75	60	150
(b) For prolonged application	10	5	20

[Revision note: Based on § 3.106]

§ 23.109 Approved acrobatic maneuvers for utility category airplanes.

Each utility category airplane must be able to safely perform all acrobatic maneuvers for which certification is requested. Safe entry speeds for these maneuvers must be determined.

[Revision note: Based on § 3.107]

§ 23.111 Acrobatic maneuvers for acrobatic category airplanes.

Each acrobatic category airplane must be able to safely perform all maneuvers for which certification is requested. Safe entry speeds for these maneuvers must be determined.

[Revision note: Based on § 3.108]

§ 23.113 Longitudinal control.

(a) It must be possible, at all speeds below the trim speed, to pitch the nose of the airplane downward so that the rate of increase in airspeed allows prompt acceleration to the trim speed with—
(1) Maximum continuous power on each engine and the airplane trimmed for V_X;
(2) Power off and the airplane trimmed for $1.5\ V_{S_1}$ or for the minimum trim speed, whichever is higher; and
(3) Wing flaps and landing gear (i) retracted, and (ii) extended.

(b) It must be shown that, with the landing gear extended, no change in trim control or exertion of more control force than can be readily applied with one hand for a short period of time is required for any of the following maneuvers:
(1) With power off, flaps retracted, and the airplane trimmed for $1.5\ V_{S_1}$, or for the minimum trim speed, whichever is higher, extend the flaps as rapidly as possible while maintaining the airspeed at approximately 40 percent above the instantaneous value of the stalling speed.
(2) Repeat subparagraph (1) except initially extend the flaps and then retract them as rapidly as possible.

(3) Repeat subparagraph (2) except with maximum continuous power.

(4) With power off, flaps retracted, and the airplane trimmed for 1.5 V_{S_1}, or for the minimum trim speed, whichever is higher, apply takeoff power quickly while maintaining the same airspeed.

(5) Repeat subparagraph (4), except with the flaps extended.

(6) With power off, flaps extended, and the airplane trimmed for 1.5 V_{S_1}, or for the minimum trim speed, whichever is higher, obtain and maintain any airspeed between 1.1 V_{S_1} and either 1.7 V_{S_1} or V_F, whichever is lower.

(c) It must be possible, without exceptional piloting skill, to maintain approximately level flight when flap retraction from any position is made during steady horizontal flight at 1.1 V_{S_1} with simultaneous application of not more than maximum continuous power.

(d) It must be possible, with a pilot control force of not more than 10 pounds, to maintain a speed of not more than 1.5 V_{S_1} during a power-off glide with landing gear and wing flaps extended, and with—

(1) The most forward center of gravity approved at the maximum weight; and

(2) The most forward center of gravity approved at any weight.

(e) It must be possible, by using all normal flight and power controls except the primary longitudinal control, to control the descent of the airplane to a zero rate of descent and to an attitude suitable for a controlled landing, without exceptional skill, alertness, or strength on the part of the pilot, and without exceeding the operational and structural limitations of the airplane.

[Revision note: Based on § 3.109]

§ 23.115 Lateral and directional control.

(a) For each multiengine airplane, it must be possible to make turns with 15 degrees of bank both towards and away from an inoperative engine, from a steady climb at 1.4 V_{S_1} or V_Y for the condition with—

(1) The remaining engine(s) at not more than maximum continuous power;

(2) The rearmost allowable center of gravity;

(3) The landing gear (i) retracted, and (ii) extended;

(4) The wing flaps in the most favorable climb position;

(5) The maximum certificated weight; and

(6) The inoperative propeller in its minimum drag condition.

(b) For each multiengine airplane, it must be possible, while holding the wings level laterally within five degrees, to execute sudden changes in heading in both directions without encountering dangerous characteristics. This must be demonstrated at 1.4 V_{S_1} or V_Y with heading changes up to 15 degrees (except that the heading change at which the rudder force corresponds to the limits specified in § 23.107 need not be exceeded), with—

(1) The critical engine inoperative;

(2) The remaining engine(s) at maximum continuous power;

(3) The landing gear (i) retracted, and (ii) extended;

(4) The wing flaps in the most favorable climb position;

(5) The inoperative propeller in its minimum drag condition; and

(6) The center of gravity at its rearmost allowable position.

[Revision note: Based on § 3.110]

§ 23.117 Minimum control speed.

(a) The minimum speed must be determined at which, when any one engine is suddenly made inoperative, it is possible to recover control of the airplane with that engine still inoperative and maintain straight flight, either with zero yaw, or, at the option of the applicant, with an angle of bank of not more than five degrees. This speed V_{MC} may not exceed 1.2 V_{S_1} with—

(1) Takeoff or maximum available power on all engines;

(2) The rearmost allowable center of gravity;

(3) The flaps in the takeoff position; and

(4) The landing gear retracted.

(b) The rudder forces required to maintain V_{MC} may not exceed the limitations set forth in § 23.107, nor may it be necessary to throttle the remaining engine or engines. During recovery, the airplane may not assume any dangerous attitude nor require exceptional skill, alertness or strength on the part of the pilot, to prevent a change of heading in excess of 20 degrees.

[Revision note: Based on § 3.111]

TRIM

§ 23.127 Trim requirements.

(a) After being trimmed, and without further pressure upon or movement of either the primary controls or their corresponding trim controls by the pilot or the automatic pilot, the airplane must maintain—

(1) Lateral and directional trim in level flight at a speed of 0.9 V_H or V_C, whichever is lower, with the landing gear and wing flaps retracted; and

(2) Longitudinal trim in—

(i) A climb with maximum continuous power at a speed between V_X and 1.4 V_{S_1}, with the landing gear and wing flaps retracted;

(ii) A climb with maximum continuous power at a speed between V_X and 1.4 V_{S_1}, with the landing gear retracted and the wing flaps in the takeoff position;

(iii) A power approach at 1.5 V_{S_1}, with a three degree angle of descent, the landing gear extended, and the wing flaps retracted;

(iv) A power approach at 1.5 V_{S_1}, with a three degree angle of descent, the landing gear and wing flaps extended, and the most forward center of gravity approved for the maximum weight;

(v) A power approach at 1.5 V_{S_1}, with a three degree angle of descent, the landing gear and wing flaps extended, and the most forward center of gravity approved for any weight; and

(vi) Level flight at any speed from 0.9 V_H to V_X or 1.4 V_{S_1}, with landing gear and wing flaps retracted.

(b) In addition to the requirements of paragraph (a) of this section, each multiengine airplane must maintain longitudinal and directional trim at a speed between V_Y and 1.4 V_{S_1}, with—

(1) The critical engine inoperative;

(2) The remaining engine(s) at maximum continuous power;

(3) The landing gear retracted;

(4) The wing flaps retracted; and

(5) An angle of bank of not more than five degrees.

[Revision note: Based on § 3.112]

STABILITY

§ 23.137 Stability.

The airplane must be longitudinally, directionally, and laterally stable in accordance with §§ 23.139 through 23.145. In addition, the airplane must show suitable stability and control "feel" (static stability) in all conditions normally encountered in service, if flight tests show that kind of stability is necessary for safe operation.

[Revision note: Based on § 3.113]

§ 23.139 Static longitudinal stability.

(a) Under the conditions specified in paragraph (b) of this section, and with the airplane trimmed as indicated, the elevator control forces and the friction within the control system must be designed in accordance with the following:

(1) A pull must be required to obtain and maintain speeds below the specified trim speed and a push required to obtain and maintain speeds above the specified trim speed. This must be shown at any speed that can be obtained without excessive control force, except speeds greater than the appropriate maximum allowable speed or less than the minimum speed for steady unstalled flight.

(2) The airspeed must return to within plus or minus 10 percent of the original trim speed when the control force is slowly released at any speed within the speed range specified in subparagraph (1) of this paragraph.

(3) The stable slope of the stick forces versus speed curve, throughout the speed ranges specified in paragraph (b) of this section, must make any substantial change in speed clearly perceptible to the pilot through resulting changes in stick forces.

(b) Compliance with the static longitudinal stability requirements of paragraph (a) of this section must be shown under the following conditions:

(1) *Approach at all speeds between 1.1 V_{S_1} and 1.8 V_{S_1}.* Under this condition the stick force curve must have a stable slope and the stick force may not exceed 40 pounds with—

(i) The wing flaps in the landing position;

(ii) The landing gear extended;

(iii) The maximum certificated weight; and

(iv) The airplane trimmed for 1.9 V_{S_1} with sufficient power to maintain a three degree angle of descent.

(2) *Climb at all speeds between 1.2 V_{S_1} and 1.6 V_{S_1}.* Under this condition the stick force curve must have a stable slope with—

(i) The wing flaps retracted;

(ii) The landing gear retracted;

(iii) The maximum certificated weight;

(iv) 75 percent of maximum continuous power; and

(v) The airplane trimmed at 1.4 V_{S_1}.

(3) *Cruising at all speeds between 1.3 V_{S_1} and the maximum allowable speed.* Under this condition the stick force curve must have a stable slope at all speeds obtainable with a stick force not exceeding 40 pounds, with—

(i) The landing gear retracted;

(ii) The wing flaps retracted;

(iii) The maximum certificated weight;

(iv) 75 percent of maximum continuous power; and

(v) The airplane trimmed for level flight.

(4) The same condition as that in subparagraph (3), except with the landing gear extended and without exceeding level flight trim speed.

[Revision note: Combines §§ 3.114 and 3.115]

§ 23.141 Instrumented stick force measurements.

Instrumented stick force measurements must be made unless changes in speed are clearly reflected by changes in stick forces and the maximum forces obtained in complying with § 23.139 are not excessive.

[Revision note: Based on § 3.116]

§ 23.143 Dynamic longitudinal stability.

Any short period oscillation occurring between the stalling speed and the maximum allowable speed must be heavily damped with the primary controls (1), free and (2), in a fixed position.

[Revision note: Based on § 3.117]

§ 23.145 Directional and lateral stability.

(a) *Three-control airplanes.* The stability requirements for three-control airplanes are as follows:

(1) The static directional stability, as shown by the tendency to recover from a skid with the rudder free, must be positive for all landing gear and flap positions appropriate to the takeoff, climb, cruise, and approach, configurations. This must be shown with symmetrical power up to maximum continuous power, and at all speeds from 1.2 V_{S_1} up to the maximum allowable speed for the condition being investigated. The angle of skid for these tests must be appropriate to the type of airplane. At greater angles of skid up to that at which full rudder is employed or a control force limit contained in § 23.107 is obtained, whichever occurs first, and at speeds from 1.2 V_{S_1} to V_A, the rudder pedal force must not reverse.

(2) The static lateral stability, as shown by the tendency to raise the low wing in a slip, must be positive for all landing gear and flap positions. This must be shown with symmetrical power up to 75 percent of maximum continuous power at all speeds above 1.2 V_{S_1}, up to the maximum allowable speed for the configuration being investigated. The static lateral stability may not be negative at a speed of 1.2 V_{S_1}. The angle of slip for these tests must be appropriate to the type of airplane but in no case may the slip angle be less than that obtainable with 10 degrees of bank.

(3) In straight, steady slips at a speed of 1.2 V_{S_1} for all landing gear and flap positions, and for all symmetrical power conditions up to 50 percent of maximum continuous power, the aileron and rudder control movements and forces must increase steadily (but not necessarily in constant proportion) as the angle of slip is increased up to the maximum appropriate to the type of airplane. At greater rudder angles up to the angle at which the full rudder or aileron control is used or a control force limit contained in § 23.107 is obtained, the rudder pedal force may not reverse. Sufficient bank must accompany slipping to hold a constant heading. Rapid entry into, or recovery from, a maximum slip may not result in uncontrollable flight characteristics.

(4) Any short period oscillation, occurring between stalling speed and the maximum permissible speed, must be heavily damped with the primary controls (i) free and (ii) in a fixed position.

(b) *Two-control (or simplified control) airplanes.* The stability requirements for two-control airplanes are as follows:

(1) The directional stability of the airplane must be demonstrated by showing that, in all configurations, it can be rapidly rolled from a 45 degree bank in one direction to a 45 degree bank in the opposite direction without showing dangerous skid characteristics.

(2) The lateral stability of the airplane must be demonstrated by showing that it will not assume a dangerous attitude or speed when all controls are abandoned for two minutes. This demonstration must be made in moderately smooth air with the airplane trimmed for straight level flight at 0.9 V_H or V_C, whichever is lower, with flaps and landing gear retracted, and with a rearward center of gravity.

(3) Any short period oscillation occurring between the stalling speed and the maximum allowable speed must be heavily damped with the primary controls (i) free and (ii) in a fixed position.

[Revision note: Based on § 3.118]

STALLS

§ 23.155 Stalling demonstration.

(a) Stalls must be demonstrated with—

(1) Power off; and

(2) A power setting of not less than that required to show compliance with § 23.73(a) for an airplane of more than 6,000 lbs. maximum weight, or with 90 percent of maximum continuous power for an airplane of 6,000 lbs. or less maximum weight.

(b) In either condition required by paragraph (a) of this section, it must be possible to comply with the applicable requirements of this section with flaps and landing gear in any position.

(c) For an airplane with independently controlled rolling and directional controls, it must be possible to produce and to correct roll by unreversed use of the rolling control and to produce and correct yaw by unreversed use of the directional control, up to the time the airplane pitches in the maneuver prescribed by paragraph (h) of this section.

(d) For an airplane with or without interconnected rolling and directional controls, it must be possible to produce and to correct roll by unreversed use of the rolling control without producing excessive yaw, up to the time the airplane pitches in the maneuver prescribed by paragraph (h) of this section.

(e) During the recovery portion of the maneuver prescribed by paragraph (h) of this section, it must be possible to prevent more than 15 degrees of roll or yaw by the normal use of the controls.

(f) Any loss of altitude greater than 100 feet, or any pitch greater than 30 degrees below flight level, occurring during the recovery portion of the maneuver prescribed by paragraph (h) of this section must be recorded in the airplane flight manual.

(g) A clear and distinctive stall warning must precede the stalling of the airplane, with the flaps and the landing gear in any position, both in straight and in turning flight. The stall warning must begin at a speed exceeding the stalling speed by not less than five and not more than 10 miles per hour, and must continue until the stall occurs.

(h) The following procedure must be used to show compliance with paragraphs (c) through (g) of this section:

(1) With the trim controls adjusted for straight flight at 1.5 V_{S_1}, or at the minimum trim speed, whichever is higher, reduce the speed by means of the elevator control until the speed is slightly above the stalling speed.

(2) Pull back the elevator control so that the rate of speed reduction will not exceed one mile per hour per second until a stall is produced, as shown by an uncontrollable downward pitching motion of the airplane, or until the control reaches the stop. Normal use of the elevator control for recovery is allowed after the pitching motion has unmistakeably developed.

(i) Except where made inapplicable by the special features of a particular type of airplane, the following procedure must be used to measure loss of altitude during a stall:

(1) The approach to the stall must be made as prescribed in paragraph (h) of this section.

(2) The loss of altitude encountered in the stall (power on or power off) is the change in altitude (as observed on the sensitive altimeter testing installation) between the altitude at which the

airplane pitches and the altitude at which horizontal flight is regained.

(3) Power used during the recovery portions of a stall maneuver may, at the discretion of the inspector, be that which would likely be used by a pilot under normal operating conditions when executing this particular maneuver. However, the power used to regain level flight may not be applied until the airplane has regained flying control at a speed of approximately 1.2 V_{S_1}. During investigation of stalls with the critical engine inoperative, the power may be reduced on the operating engine or engines before reapplying power for the purpose of regaining level flight.

[Revision note: Combines §§ 3.120 and 3.120-1 (less 1st sentence)]

§ 23.157 Climbing stalls.

It must be possible, when stalled from an excessive climb attitude, to recover without exceeding airspeed or acceleration limits.

[Revision note: Based on § 3.121]

§ 23.159 Turning flight stalls.

(a) When stalled during a coordinated turn with 30 degrees of bank, 75 percent maximum continuous power on each engine, and flaps and landing gear retracted, it must be possible to regain normal level flight without excessive loss of altitude or uncontrollable rolling or spinning tendencies.

(b) The following maneuver must be used to show compliance with paragraph (a) of this section. Establish a steady, curvilinear, level, coordinated turn in a 30 degree bank and, while maintaining the 30 degree bank, stall the airplane by steadily and progressively tightening the turn with the elevator control until the airplane is stalled, or until the elevator has reached its stop. When the stall has fully developed, regain level flight with normal use of the controls.

[Revision note: Based on § 3.122]

§ 23.161 One-engine inoperative stalls.

(a) A multiengine airplane must have stall characteristics which preclude unintentional spin entry. These characteristics must be shown by performing the maneuver prescribed in paragraph (b) of this section, at the lowest practical altitude, with—

(1) The critical engine inoperative and its propeller in the normal inoperative position;

(2) Landing gear extended, with the flaps (i) retracted and (ii) extended; and

(3) The remaining engine(s) operating at full throttle or maximum continuous power.

(b) The following maneuver must be used to show that unintentional spin entry is impossible. Establish a steady, curvilinear turn and, while maintaining a 15 degree bank (1), toward and (2) away from the inoperative engine, steadily increase the angle of attack with the elevator control until an uncontrollable downward pitching motion of the airplane occurs. In performing this maneuver, it must be possible to—

(1) Produce and correct roll by unreversed use of the lateral control until the airplane stalls; and

(2) Recover immediately to full flight control with wings level, from the stalled condition, by normal use of the controls, reducing power on the operating engine or engines if desired, without the airplane exceeding a 60 degree angle of bank.

(c) The loss of altitude (as measured from the altitude at which the airplane starts to pitch uncontrollably to the altitude at which level flight is regained and the pitch angle must be recorded in the airplane flight manual.

[Revision note: Based on § 3.123]

SPINNING

§ 23.171 Spinning.

(a) *Normal category airplanes.* A single-engine, normal category airplane must be able to recover from a one-turn spin in not more than one additional turn, with the controls used in the manner normally used for recovery. For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor may not be exceeded. For the flaps-extended condition, the flaps may be retracted during recovery. In addition, there may be no excessive back pressure during the spin or recovery. It may not be possible to obtain uncontrollable spins with any possible use of the controls. Each normal category airplane, regardless of weight, must be placarded against spins unless it is shown to be "characteristically incapable of spinning", in which case it must be so designated.

(b) *Utility category airplanes.* A utility category airplane must conform to either all of the requirements of paragraph (a) of this section or all of the requirements of paragraph (c) of this section.

(c) *Acrobatic category airplanes.* An acrobatic category airplane must be able to spin at least six turns, and must be able to conform to the following requirements:

(1) The airplane must recover from any point in a spin, not exceeding six turns with flaps retracted and one turn with flaps extended, in not more than one and one-half additional turns after normal recovery application of the controls.

(2) For both the flaps-retracted and flaps-extended conditions, the applicable airspeed limit and positive limit maneuvering load factor may not be exceeded. For the flaps-extended condition, the flaps may be retracted during recovery, if a placard is installed prohibiting intentional spins with flaps extended.

(3) It may not be possible to obtain uncontrollable spins with any use of the controls.

(4) A placard listing the use of the controls required to recover from spinning maneuvers must be in the cockpit of the airplane.

(d) If the applicant desires to designate an airplane as a type "characteristically incapable of spinning", he must show this characteristic with—

(1) A maximum weight five percent greater than the weight for which approval is requested;

(2) A center of gravity at least three percent aft of the rearmost position for which approval is requested;

(3) An available elevator up-travel four degrees in excess of that to which the elevator travel is to be limited for approval; and

(4) An available rudder travel seven degrees, in both directions, in excess of that to which the rudder travel is to be limited for approval.

[Revision note: Based on § 3.124]

GROUND AND WATER CHARACTERISTICS

§ 23.181 Longitudinal stability and control.

A landplane may not have any uncontrollable tendency to nose over in any reasonably expected operating condition or when rebound occurs during landing or takeoff. Wheel brakes must operate smoothly and may not induce any undue tendency to nose over. A seaplane may not exhibit dangerous or uncontrollable porpoising at any speed at which it is normally operated on the water.

[Revision note: Based on § 3.144]

§ 23.183 Directional stability and control.

(a) There may be no uncontrollable ground or water looping tendency in 90 degree cross winds, up to a velocity equal to 0.2 V_{S_0}, at any speed at which the aircraft may be expected to be operated upon the ground or water.

(b) A landplane must be satisfactorily controllable, without exceptional skill or alertness on the part of the pilot, in power-off landings at normal landing speed, with neither brakes nor engine power used to maintain a straight path.

(c) The airplane must have adequate directional control during taxiing.

[Revision note: Based on § 3.145]

§ 23.185 Shock absorption.

The shock-absorbing mechanism may not damage the structure of the airplane when it is taxied on the roughest ground that it is reasonable to expect the airplane to meet in normal operation.

[Revision note: Based on § 3.146]

§ 23.187 Spray characteristics for seaplanes.

Spray may not dangerously obscure the vision of the pilot or pilots or damage the propeller or other parts of a seaplane at any time during taxiing, takeoff, and landing.

[Revision note: Based on § 3.147]

VIBRATION AND BUFFETING

§ 23.197 Vibration and buffeting.

Each part of the airplane must be free from excessive vibration under all speed and power conditions appropriate to the operation of the airplane, up to at least the minimum value permitted for V_D in § 23.245. In addition, there may be no buffeting in any normal flight condition severe enough to interfere with the satisfactory control of the airplane, cause

excessive fatigue to the crew, or result in structural damage.

[Revision note: Based on § 3.169]

Subpart C—Strength Requirements

§ 23.217 Loads.

(a) Strength requirements are specified in terms of—

(1) Limit loads, which are the maximum loads to be expected in service. Unless otherwise specified, all prescribed loads are limit loads.

(2) Ultimate loads, which are limit loads multiplied by prescribed factors of safety.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering all items of mass in the airplane. Each of these loads must be distributed in a manner conservatively approximating or closely representing actual conditions. If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

(c) Simplified structural design criteria may be used if the Administrator finds that they result in design loads not less than those prescribed in §§ 23.233 through 23.441. For conventional, single-engine airplanes with design weights of 6,000 pounds or less, the design criteria of Appendix A of this part are an approved equivalent of §§ 23.233 through 23.359. If Appendix A is used, the entire Appendix must be substituted for the corresponding sections of this part.

[Revision note: Combines §§ 3.171 and 1.0 of Appendix A]

§ 23.219 Factor of safety.

Unless otherwise specified in this part, a factor of safety of 1.5 must be used.

[Revision note: Based on § 3.172]

§ 23.221 Strength and deformation.

Each structure must be capable of supporting limit loads without suffering detrimental, permanent deformation. At all loads up to limit loads, the deformation must not interfere with the safe operation of the airplane. The structure must be capable of supporting ultimate loads without failure for at least three seconds. However, when proof of strength is demonstrated by dynamic tests simulating actual load conditions, the three-second limit does not apply.

[Revision note: Based on § 3.173]

§ 23.223 Proof of structure.

Each structure must conform to the strength and deformation requirements of § 23.221 for all critical load conditions. Proof of compliance by structural analysis is acceptable only when the structure conforms to types for which experience has shown such methods to be reliable. In all other cases, substantiating load tests are required. Dynamic tests, including structural flight tests, are acceptable if it is shown that the design load conditions have been simulated. Certain parts of the structure must be tested as specified in Subpart D of this part.

[Revision note: Based on § 3.174]

Flight Loads

§ 23.233 Flight loads.

(a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the airplane) to the weight of the airplane. A positive flight load factor is an aerodynamic force acting upward, with respect to the airplane.

(b) The airplane must conform to the flight load requirements in this part at critical altitudes within the range in which the airplane may be expected to operate and at all weights between the minimum design weight and the maximum design weight, with any practicable distribution of disposable load within prescribed operating limitations stated in §§ 23.1543 through 23.1547.

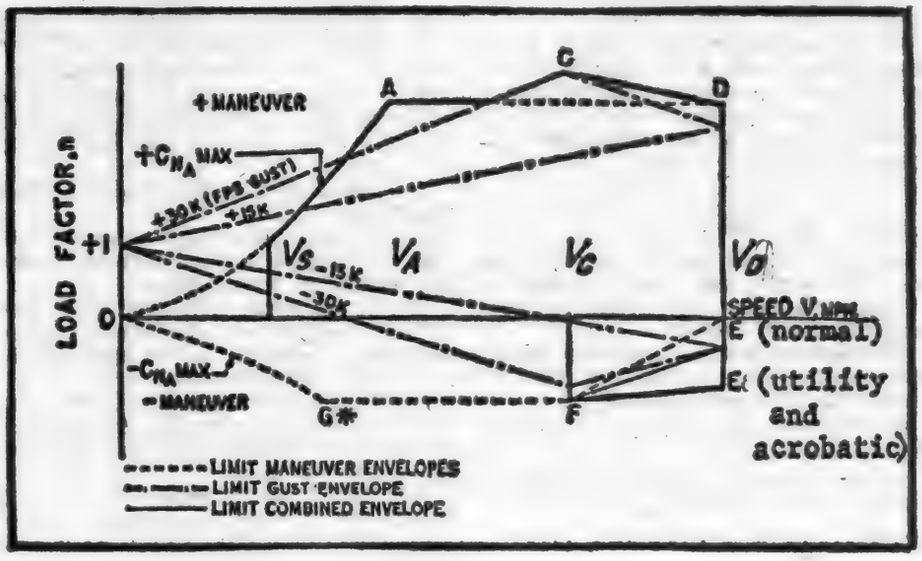
[Revision note: Combines §§ 3.181 and 3.182]

SYMMETRICAL FLIGHT CONDITIONS (FLAPS RETRACTED)

§ 23.243 General.

(a) The strength requirements must be met at all combinations of airspeed and load factor on and within the boundaries of a pertinent V–n diagram (similar to the one in paragraph (b) of this section) that represents the envelope of the flight loading conditions specified by the maneuvering and gust criteria of §§ 23.247 and 23.251, respectively.

(b) V–n diagram (flight envelope).



NOTE: Point G need not be investigated when the supplementary condition specified in § 23.285 is investigated.

[Revision note: Combines § 3.183 and Figure 3–1]

§ 23.245 Design airspeeds.

The selected design airspeeds must be equivalent airspeeds (EAS) of not less than the values derived from the following formulas:

(a) V_C (design cruising speed, m.p.h.)
$=38\sqrt{W/S}$ (for normal and utility category airplanes).
$=42\sqrt{W/S}$ (for acrobatic category airplanes).

For values of W/S greater than 20, the numerical multiplying factors must be decreased linearly with W/S to a value of 33 where $W/S=100$. The required minimum value need not be greater than 0.9 V_H actually obtained at sea level.

(b) V_D (design dive speed)
$=1.40\ V_{C\ min}$ (for normal category airplanes).
$=1.50\ V_{C\ min}$ (for utility category airplanes.
$=1.55\ V_{C\ min}$ (for acrobatic category airplanes).

For values of W/S greater than 20, the numerical multiplying factors must be decreased linearly with W/S to a value of 1.35 at $W/S=100$. $V_{C\ min}$ is the required minimum design cruising speed.

(c) V_A (design maneuvering speed, m.p.h.)
$=V_S\sqrt{n}$

where—

V_S = a computed stalling speed with flaps retracted at the design weight, normally based on the maximum airplane normal force coefficient, C_{N_A}; and

n = limit maneuvering load factor used in design.

The value of V_A need not exceed the value of V_C used in design.

[Revision note: Based on § 3.184]

§ 23.247 Maneuvering envelope.

Except where limited by maximum (static) lift coefficients, the airplane is assumed to be subjected to symmetrical maneuvers resulting in the following limit load factors:

(a) The positive maneuvering load factor specified in § 23.249 at all speeds up to V_D;

(b) The negative maneuvering load factor specified in § 23.249 at speed V_C; and

(c) Factors varying linearly with speed from the specified value at V_C to 0.0 at V_D for the normal category, and −1.0 at V_D for the acrobatic and utility categories.

[Revision note: Based on § 3.185]

§ 23.249 Limit maneuvering load factors.

(a) Positive limit maneuvering load factors may not be less than those derived as follows:

(1) $n=2.1+\frac{24{,}000}{W+10{,}000}$ for normal category airplanes except that n need not be greater than 3.8 nor may it be less than 2.5.

(2) $n=4.4$ for utility category airplanes.

(3) $n=6.0$ for acrobatic category airplanes.

(b) Negative limit maneuverng load factors not less than −0.4 times the positive load factor for the normal and utility categories, and not less than −0.5 times the positive load factor for the acrobatic category, must be used.

(c) Maneuvering load factors lower than those specified in paragraphs (a) and (b) of this section may be used if the airplane has designed features which make it impossible for the airplane to exceed these values in flight.

[Revision note: Based on § 3.166]

§ 23.251 Gust envelope.

(a) Limit loads are considered to be the loads which would result when the airplane encounters the following symmetrical vertical gusts:

(1) Positive (up) and negative (down) gusts of 30 feet per second nominal intensity at all speeds up to V_G.

(2) Positive and negative gusts of 15 feet per second at V_D.

(b) Gust load factors are assumed to vary linearly between V_G and V_D.

[Revision note: Based on § 3.167]

§ 23.253 Gust load factors.

In applying gust load requirements, the slope of the lift curve may be assumed to be that of the wing alone, and the gust load factors must be computed using the following formula:

$$n=1+\frac{KUVm}{575(W/S)}$$

where—

$K=\frac{1}{2}(W/S)^{1/4}$ (for $W/S<16$ p.s.f.);

$K=1.33-\frac{1.67}{(W/S)^{3/4}}$ (for $W/S>16$ p.s.f.);

U = nominal gust velocity, f.p.s. (Note that the "effective sharp-edged gust" equals KU);

V = airplane speed, m.p.h.;

m = slope of lift curve, C_L per radian, corrected for aspect ratio;

W/S = wing loading, p.s.f.

[Revision note: Combines §§ 3.168 and 3.168–1]

§ 23.255 Airplane equilibrium.

(a) The appropriate balancing horizontal tail load must be accounted for in a rational or conservative manner when determining the wing loads and linear inertia loads corresponding to any of the flight conditions specified in §§ 23.243 through 23.253.

(b) The incremental horizontal tail loads due to maneuvering and gusts must be reacted by the angular inertia of the complete airplane in a rational or conservative manner.

[Revision note: Based on § 3.169]

FLAPS EXTENDED FLIGHT CONDITIONS

§ 23.265 Flaps extended flight conditions.

(a) If flaps or other high lift devices (intended for use at the relatively low airspeeds of approach, landing, and takeoff) are installed, the airplane, with the flaps fully deflected at the design flap speed V_F, is assumed to be subjected to symmetrical maneuvers and gusts resulting in limit load factors within the range determined by the conditions specified in subparagraphs (1) and (2) of this paragraph. V_F must be assumed to be not less than 1.4 V_S or 1.8 V_{SF}, whichever is greater, where—

V_S = the computed stalling speed with flaps retracted at the design weight; and

V_{SF} = the computed stalling speed with flaps fully extended at the design weight.

However, if an automatic flap load limiting device is used, the airplane may be designed for the critical combinations of airspeed and flap position allowed by that device.

(1) Maneuvering, to a positive limit load factor of 2.0.

(2) Positive and negative gusts of 15 feet per second acting normal to the flight path in level flight.

(b) In designing the flaps and supporting structures, slipstream effects must be accounted for, as specified in paragraph (b) of § 23.347.

(c) In determining external loads on the airplane as a whole, thrust, slipstream, and pitching acceleration may be assumed to be zero.

(d) The requirements of §§ 23.139 (b) (1), 23.347, and this section, may be complied with separately or in combination.

[Revision note: Combines §§ 3.190, 3.190 (Note), and 3.190–1]

UNSYMMETRICAL FLIGHT CONDITIONS

§ 23.275 Unsymmetrical flight conditions.

Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces. The airplane must meet the following requirements:

(a) *Rolling conditions.* The wing and wing bracing must be designed for the following loading conditions:

(1) Unsymmetrical wing loads appropriate to the airplane category. Unless the Administrator finds that the following values result in unrealistic loads, the rolling accelerations may be obtained by modifying the symmetrical flight conditions in § 23.243(b) as follows:

(i) For acrobatic category airplanes, in conditions A and F, assume that 100 percent of the wing airload acts on one side of the plane of symmetry and 60 percent of this load acts on the other side.

(ii) For normal and utility category airplanes, in condition A, assume that 100 percent of the wing airload acts on one side of the airplane and 70 percent of this load acts on the other side. For airplanes of more than 1,000 pounds design weight, the latter percentage may be increased linearly with weight up to 75 percent at 12,500 pounds.

(2) The loads resulting from the aileron deflections and speeds specified in § 23.345, in combination with an airplane load factor of at least two thirds of the positive maneuvering load factor used for design. Unless the Administrator finds that the following values result in unrealistic loads, the effect of aileron displacement on wing torsion may be accounted for by adding the following increment to the basic airfoil moment coefficient over the aileron portion of the span in the critical condition determined in § 23.243(b):

$\Delta cm=-0.01\delta$

where—

Δcm is the moment coefficient increment; and δ is the down aileron deflection in degrees in the critical condition.

(b) *Yawing conditions.* The airplane must be designed for yawing loads resulting from the loads specified in §§ 23.331 through 23.335, on the vertical tail surfaces.

[Revision note: Based on § 3.191]

SUPPLEMENTARY CONDITIONS

§ 23.285 Special conditions for rear lift truss.

(a) If a rear lift truss is used, it must be designed for conditions of reversed airflow at a design speed of—

$V=10\sqrt{W/S}+10$ (m.p.h.).

(b) Aerodynamic data for the particular wing section used, or a value of C_L equalling −0.8 with a chordwise distribution that is triangular between a peak at the trailing edge and zero at the leading edge, must be used.

[Revision note: Based on § 3.194]

§ 23.287 Engine torque effects.

(a) Each engine mount and its support structure must be designed for the effects of—

(1) The limit torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads flight condition A;

(2) The limit torque corresponding to maximum continuous power and propeller speed, acting simultaneously with the limit loads from flight condition A; and

(3) The limit torque obtained by multiplying the mean torque by a factor of 1.33 for engines with five or more cylinders, or by factors of 2, 3, or 4 for engines with 4, 3, or 2 cylinders, respectively.

(b) Engine torque effects need not be investigated for any other conditions.

[Revision note: Based on § 3.195]

§ 23.289 Side load on engine mount.

The limit load factor in a lateral direction for the side load on the engine mount must be at least equal to one-third of the limit load factor for flight condition A, but may not be less than 1.33. Each engine mount and its supporting structure must be designed for this side load, which may be assumed to be independent of other flight conditions.

[Revision note: Based on § 3.196]

§ 23.291 Pressurized cabin loads.

In the case of a pressurized compartment, the following requirements must be met:

(a) The airplane structure must be strong enough to withstand the flight loads combined with pressure differential loads from zero up to the maximum relief valve setting. The external pressure distribution in flight must be accounted for. Stress concentrations must be accounted for in the design of the pressurized structure.

(b) If landings with the cabin pressurized are to be allowed, landing loads must be combined with pressure differential loads from zero up to the maximum expected during landing.

(c) The airplane structure must be strong enough to withstand the pressure differential loads corresponding to the maximum relief valve setting multiplied by a factor of 1.33. All other loads may be omitted in this case.

(d) If a pressurized cabin is separated into two or more compartments by bulkheads or a floor, the primary structure must be designed for the effects of sudden release of pressure in any compartment with external doors or windows. This condition must be investigated for the effects of failure of the largest opening in the compartment. The effects of intercompartmental venting may be considered.

[Revision note: Based on § 3.197]

CONTROL SURFACE LOADS

§ 23.301 Control surface loads.

(a) The control surface loads specified in §§ 23.303 through 23.351 are assumed to occur in the symmetrical and unsymmetrical flight conditions described in §§ 23.255 through 23.275.

(b) If allowed by the following sections, the values of control surface loading in Appendix B of this part may be used instead of using particular control surface data, to determine the detailed rational requirements of §§ 23.303 through 23.351, unless the Administrator finds that these values result in unrealistic loads.

[Revision note: Based on § 3.211]

§ 23.303 Pilot effort effects.

(a) *Airloads.* Compliance with the control surface loading requirements of this part must be shown with movable surface airloads and deflections which need not exceed the loads which would result in flight from the application of any pilot load within the ranges specified in paragraph (b) of this section. In applying this criterion, consider the effects of control system boost and servomechanisms, and the effects of tabs. In addition, the automatic pilot effort must be used for design if it alone can produce greater control surface loads than the human pilot.

(b) *Limit pilot loads.*

Control	Maximum loads for design weight W equal to or less than 5,000 pounds [1]	Minimum loads [2]
Aileron:		
Stick	67 pounds	40 pounds.
Wheel [3]	53 D in-pounds [4]	40 D in-pounds.[4]
Elevator:		
Stick	167 pounds	100 pounds.
Wheel	200 pounds	100 pounds.
Rudder	200 pounds	130 pounds.

[1] For design weight (W) greater than 5,000 pounds, the specified maximum values must be increased linearly with weight to 1.18 times the specified values at a design weight of 12,500 pounds.

[2] If the design of any individual set of control systems or surfaces makes these specified minimum loads inapplicable, values corresponding to the pertinent hinge moments obtained in accordance with § 23.361 but not less than 0.6 of the specified minimum loads, may be used.

[3] The critical portions of the aileron control system must also be designed for a single tangential force with a limit value of 1.25 times the couple force determined from the above criteria.

[4] D=wheel diameter.

[Revision note: Combines §§ 3.212. Figure 3-11, and 3.212-1]

§ 23.305 Trim tab effects.

The effects of trim tabs on the control surface design conditions must be considered only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction which would assist the pilot. This deflection must correspond to the maximum degree of "out of trim" expected at the speed for the condition under consideration.

[Revision note: Based on § 3.213]

HORIZONTAL TAIL SURFACES

§ 23.315 Balancing loads.

(a) A horizontal tail balancing load is the load that is necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.

(b) Horizontal tail surfaces must be designed for the balancing loads occurring at any point on the limit maneuvering envelope and in the flap conditions specified in § 23.265. The distribution in figure 6 of Appendix B may be used instead of this requirement.

[Revision note: Based on § 3.215 and the note]

§ 23.317 Maneuvering loads.

Each horizontal tail surface must be designed for maneuvering loads imposed by the following conditions:

(a) At maneuvering speed V_A, a sudden deflection of the elevator control to the maximum upward deflection, as limited by the control stops, or pilot effort, whichever is critical. The average loading of B23.11 of Appendix B and the distribution in figure 7 of Appendix B may be used instead of this requirement.

(b) The same as case (a), except for downward elevator deflection. The average loading of B23.11 of Appendix B and the distribution of figure 7 of Appendix B may be used instead of this requirement.

(c) At all speeds above V_A, a sudden upward deflection of the elevator followed by a downward deflection of the elevator, resulting in the following combinations of normal and angular acceleration:

Condition	Normal acceleration (n)	Angular acceleration (radian/sec.^{2})
Down load	1.0	$\frac{+45}{V} n_m (n_m - 1.5)$
Up load	n_m	$\frac{-45}{V} n_m (n_m - 1.5)$

where—

(1) n_m=positive limit maneuvering load factor used in the design of the airplane; and

(2) V=initial speed in miles per hour.

The conditions in this paragraph involve loads corresponding to the loads that may occur in a "checked maneuver" (a maneuver in which the pitching control is suddenly displaced in one direction and then suddenly moved in the opposite direction), the deflections and timing avoiding exceeding the limit maneuvering load factor. The total tail load for both down and up load conditions is the sum of the balancing tail loads at speed V and the specified value of the normal load factor (n), plus the maneuvering load increment due to the specified value of the angular acceleration. The maneuvering load increment in figure 2 of Appendix B and the distributions in figure 7 (for down loads) and in figure 8 (for up loads) of Appendix B may be used instead of this requirement.

[Revision note: Based on § 3.216 and the notes following § 3.216 (a), (b), and (d)]

§ 23.319 Gust loads.

(a) Each horizontal tail surface must be designed for loads resulting from—

(1) Positive and negative gusts of 30 feet per second nominal intensity at V_C, corresponding to the flight condition specified in § 23.251(a) with flaps retracted; and

(2) Positive and negative gusts of 15 feet per second nominal intensity at speed V_F, corresponding to the flight condition specified in § 23.265(a)(2) with flaps extended and at V_D corresponding with the flight conditions specified in § 23.251(a)(2) with flaps retracted.

(b) The average loadings in figures 3 and 4 of Appendix B and the distribution in figure 8 of Appendix B may be used instead of the requirements of subparagraph (a)(1).

(c) When determining the total load on the horizontal tail for the conditions specified in paragraph (a) of this section, the initial balancing tail loads for steady unaccelerated flight at the pertinent design speeds V_F, V_C, V_D must first be determined. The incremental tail load resulting from the gusts must be added to the initial balancing tail load to obtain the total tail load.

(d) The incremental tail load due to the gust may be computed by the following formula:

$$\Delta t = 0.1 K U V S_t a_t \left[\frac{1 - 36 a_w}{R_w}\right]$$

where—

Δt = the limit gust load increment on the tail in pounds;
K = gust coefficient K derived from § 23.253;
U = nominal gust intensity in feet per second;
V = airplane speed in miles per hour;
S_t = tail surface area in square feet;
a_t = slope of lift curve of tail surface, C_L per degree, corrected for aspect ratio;
a_w = slope of lift curve of wing, C_L per degree; and
R_w = aspect ratio of the wing.

[Revision note: Based on § 3.217 (and the note following § 3.217(a))]

§ 23.321 Unsymmetrical loads.

The maximum horizontal tail surface loading (load per unit area), as determined in accordance with §§ 23.315 through 23.319, must be applied to the horizontal surfaces on one side of the plane of symmetry and the following percentage of that loading must be applied to the opposite side:

$\% = 100 - 10(n-1)$ where n is the specified positive maneuvering load factor.

This value may not be greater than 80 percent.

[Revision note: Based on § 3.218]

VERTICAL TAIL SURFACES

§ 23.331 Maneuvering loads.

(a) At all speeds up to V_A, the vertical tail surfaces must be designed to withstand the loads from—

(1) A sudden displacement of the rudder control (with the airplane in unaccelerated flight with zero yaw) to the maximum deflection allowed by the control stops or by pilot strength, whichever is critical;

(2) A yaw angle of 15 degrees with the rudder fully deflected (except as limited by pilot strength) in the direction tending to increase the slip; and

(3) A yaw angle of 15 degrees with the rudder control maintained in the neutral position (except as limited by pilot strength).

(b) The average loading of B23.11 and figure 1 of Appendix B and the distribution in figures 7, 6, and 8 of Appendix B may be used instead of the requirements of subparagraphs (a)(1), (a)(2), and (a)(3), respectively.

(c) The yaw angles specified in paragraph (a)(3) of this section may be reduced if the yaw angle chosen for a particular speed cannot be exceeded in—

(1) Steady slip conditions;

(2) Uncoordinated rolls from steep banks; and

(3) Sudden failure of the critical engine with delayed corrective action.

[Revision note: Based on § 3.219 and notes]

§ 23.333 Gust loads.

(a) Vertical tail surfaces must be designed to withstand, in unaccelerated flight at V_G, a gust of 30 feet per second nominal intensity normal to the plane of symmetry.

(b) The gust loading for that part of a vertical tail surface with a well defined leading edge must be computed by the following formula:

$$\bar{w} = \frac{KUVm}{575}$$

where—

$\bar{w}$ = average limit unit pressure in pounds per square foot;

$K = 1.33 - \frac{4.5}{(W/S_v)^{3/4}}$, except that K may not be less than 1.0.

However, a value of K obtained by rational determination may be used;

U = nominal gust intensity in feet per second;

$= u$ airplane speed in miles per hour;

V = slope of lift curve of vertical surface, C_L per radian, corrected for aspect ratio;

W = design weight in pounds; and

S_v = vertical surface area in square feet.

(c) The average loading in figure 5 and the distribution in figure 8 of Appendix B may be used instead of the requirements of this section.

[Revision note: Based on § 3.220]

§ 23.335 Outboard fins.

(a) If outboard fins are on the horizontal tail surface, the tail surfaces must be designed for the maximum horizontal surface load in combination with the corresponding loads induced on the vertical surfaces by endplate effects. These induced effects need not be combined with other vertical surface loads.

(b) If outboard fins extend above and below the horizontal surface, the critical vertical surface loading (the load per unit area as determined in accordance with §§ 23.331 and 23.333) must be applied to—

(1) The part of the vertical surfaces above the horizontal surface with 80 percent of that loading applied to the part below the horizontal surface; and

(2) The part of the vertical surfaces below the horizontal surface with 80 percent of that loading applied to the part above the horizontal surface.

[Revision note: Based on § 3.221]

AILERONS, WING FLAPS, TABS, ETC., AND SPECIAL DEVICES

§ 23.345 Ailerons.

(a) The ailerons must be designed for all loads that they are subjected to while in the neutral position during symmetrical flight conditions.

(b) The ailerons must be designed for all loads that they are subjected to by the following deflections (except as limited by pilot effort) during unsymmetrical flight conditions:

(1) Sudden maximum displacement of the aileron control at speed V_A. Suitable allowance may be made for control system deflections.

(2) Sufficient deflection at V_G, where V_G is greater than V_A, to produce a rate of roll not less than that obtained in subparagraph (1).

(3) Sufficient deflection at V_D to produce a rate of roll not less than one-third of that obtained in subparagraph (1).

(c) The average loading in § 23.11 and figure 1 of Appendix B and the distribution in figure 9 of Appendix B may be used instead of the requirements of this section.

[Revison note: Based on § 3.222 (less (c) and (d))]

§ 23.347 Wing flaps.

(a) The wing flaps, their operating mechanisms, and supporting structures must be designed for critical loads occurring in the flaps-extended flight conditions with the flaps in any position. However, if an automatic flap load limiting device is used, these components may be designed for the critical combinations of airspeed and flap position allowed by that device.

(b) The effects of propeller slipstream, corresponding to takeoff power, must be taken into account at an airplane speed of not less than 1.4 V_S, where V_S is the computed stalling speed with flaps fully retracted at the design weight. For the investigation of slipstream effects, the load factor may be assumed to be 1.0.

[Revision note: Based on § 3.223]

§ 23.349 Tabs.

Control surface tabs must be designed for the most severe combination of airspeed and tab deflection likely to be obtained within the limit V–n diagram for any usable loading condition of the airplane.

[Revision note: Based on § 3.224]

§ 23.351 Special devices.

The loading for special devices employing aerodynamic surfaces, such as slots and spoilers, must be determined from test data.

[Revision note: Based on § 3.225]

CONTROL SYSTEM LOADS

§ 23.357 Primary flight controls and systems.

(a) Each flight control system and its supporting structure must be designed for loads corresponding to at least 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in §§ 23.301 through 23.351. In addition, the following applies:

(1) The system limit loads need not exceed the greater of the loads which can be produced by the pilot and automatic devices operating the controls. However, autopilot loads need not be added to pilot loads. The system must be designed for the maximum effort of the pilot or autopilot, whichever is greater. In addition, if the pilot and the autopilot act in opposition, the part of the system between them may be designed for the maximum effort of the one that imposes the lesser load.

(2) The design must, in any case, provide a rugged system for service use, considering jamming, ground gusts, taxiing downwind, control inertia, and friction.

(b) A 125 percent factor on computed hinge moments must be used to design elevator, aileron, and rudder systems. A factor as low as 1.0 may be used if hinge moments are based on accurate flight test data. However, the exact re-

duction depends upon the accuracy and reliability of the data. Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in § 23.303(b). These pilot loads are assumed to act at the appropriate control grips or pads as they would in flight, and to react at the attachments of the control system to the control surface horns.

[Revision note: Combines §§ 3.231, 3.231–1 (1st and 4th sentences), and 3.231–2]

§ 23.359 Dual controls.

If dual controls are installed, the systems must be designed for the pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with § 23.357. Each pilot load may not, however, be less than the minimum load specified in § 23.303(b).

[Revision note: Based on § 3.232]

§ 23.361 Ground gust conditions.

(a) If pilot effort loads less than those specified in the minimum loads column of § 23.303(b) are used for design, the effects of surface loads due to ground gusts and taxiing downwind must be investigated for the entire control system according to the following formula:

$H = KcSq$

where—

H=limit hinge moment (foot-pounds);

c=mean chord of the control surface aft of the hinge line (feet);

S=area of control surface aft of the hinge line (square feet);

q=dynamic pressure (pounds per square foot) based on a design speed not less than $10\sqrt{W/S}+10$ miles per hour, except that the design speed need not exceed 60 miles per hour; and

K=factor as specified below. (In connection with ailerons and elevators, a positive value of K indicates a moment tending to depress the surface while a negative value of K indicates a moment tending to raise the surface.)

Surfaces	K
(1) Aileron. Control column locked or lashed in mid-position.	+0.75
(2) Aileron. Ailerons at full throw; +moment on one aileron, −moment on the other.	±0.50
(3)(4) Elevator. Elevator (3) full up (−), and (4) full down (+).	±0.75
(5)(6) Rudder. Rudder (5) in neutral, and (6) at full throw.	±0.75

(b) If an investigation of the control system for ground gust loads is not required by paragraph (a) of this section but the applicant elects to design a part of the control system for these loads, the ground gust loads need only be carried from control surface horns through the nearest stops or gust locks and their supporting structures.

[Revision note: Combines §§ 3.233 and 3.233–1]

§ 23.363 Secondary controls and systems.

Secondary controls, such as wheel brakes, spoilers, and tab controls, must be designed for the loads resulting from the maximum effort that a pilot is likely to apply to those controls.

[Revision note: Based on § 3.234]

Ground Loads

§ 23.369 Ground loads.

The loads specified in the following conditions are considered to be external loads and inertia forces that act upon an airplane structure. In each of the specified ground load conditions, the external reactions must be rationally or conservatively placed in equilibrium with the linear and angular inertia forces.

[Revision note: Based on § 3.241]

§ 23.371 Design landing weight.

(a) Except as provided in paragraphs (b) and (c) of this section, the design landing weight may not be less than the maximum weight for which the airplane is to be certificated.

(b) The design landing weight may be as low as 95 percent of the maximum certificated weight if—

(1) The structural limit load values at the maximum certificated weight are not exceeded when the airplane is operated at all speeds up to takeoff speed over terrain as rough as that expected in service;

(2) The minimum fuel capacity is not less than the sum of the capacities prescribed in § 23.841 plus the capacity equal to a fuel weight equal to the difference between the maximum certificated weight and the design landing weight; and

(3) The operating limitations limit the takeoff weight to assure that landing weights in normal operation do not exceed the design landing weight.

(c) The design landing weight of a multiengine airplane may be less than 95 percent of the maximum certificated weight if—

(1) The airplane meets the one-engine-inoperative climb requirements of § 23.73(c) or § 23.75 (b) and (c); and

(2) Instead of the corresponding requirements of this part, compliance is shown with the following requirements of Part 25 [New] (present Part 4b):

(i) The ground load requirements of § ——— (present § 4b.230).

(ii) The landing gear requirements of §§ ——— through ——— (present §§ 4b.331 through 4b.336).

(iii) The fuel jettisoning system requirements of § ——— (present § 4b.437).

(d) The design landing weight may be used only for structural design purposes.

[Revision note: Combines §§ 3.242 and 3.85–4 (last sentence)]

§ 23.373 Load factor for landing conditions.

The applicant must choose the limit vertical inertia load factor at the center of gravity of the airplane for the following landing conditions. However, it may not be less than the value that would be obtained when landing the airplane with a descent velocity (V), in feet per second, equal to 4.4 $(W/S)^{1/4}$, except that the descent velocity need not be more than 10 feet per second and may not be less than seven feet per second. Wing lift not exceeding two-thirds of the weight of the airplane may be assumed to exist throughout the landing impact and to act through the center of gravity. Under these assumptions, the ground reaction load factor may be taken to be equal to the inertia load factor minus the ratio of the above assumed wing lift to the airplane weight. The energy absorption tests (to determine the limit load factor corresponding to the required limit descent velocities) must be made in accordance with § 23.613. However, no inertia load factor used for design purposes may be less than 2.67, nor may the limit ground reaction load factor be less than 2.0, unless it is shown that the lower values of limit load factor will not be exceeded in taxiing the airplane at all speeds up to takeoff speed over terrain as rough as that expected in service.

[Revision note: Based on § 3.243]

Landing Cases and Attitudes

§ 23.383 General.

(a) For conventional arrangements of main and nose, or main and tail wheels, it is assumed that the airplane contacts the ground at the specified limit vertical velocity in the attitudes described in §§ 23.385 through 23.389.

(b) The conditions in Appendix C conform to §§ 23.385 through 23.389.

[Revision note: Based on § 3.244]

§ 23.385 Level landing.

(a) The airplane is assumed to be in the following attitudes:

(1) For tail wheel type airplanes, a normal level flight attitude.

(2) For nose wheel type airplanes, attitudes in which—

(i) The nose and main wheels contact the ground simultaneously; and

(ii) The main wheels contact the ground and the nose wheel is just clear of the ground. (The same angular attitude as was used in subdivision (i) of this subparagraph may be used in this analysis.)

(b) When investigating landing conditions, the drag components stimulating the forces required to accelerate the tires and wheels up to the landing speed must be properly combined with the corresponding instantaneous vertical ground reactions, assuming wing lift and a tire-sliding coefficient of friction of 0.8. However, the drag loads may not be less than 25 percent of the maximum vertical ground reactions (neglecting wing lift).

(c) In determining the wheel spin-up loads for landing conditions, the method set forth in Appendix D may be used if a more rational method than the use of the arbitrary drag components referred to in § 23.383(b) is desired. However, the 25 percent value for the minimum drag component must be used.

[Revision note: Combines §§ 3.245 and 3.245–1(b) (before equation)]

§ 23.387 Tail down landing.

(a) The airplane is assumed to be in the following attitudes:

(1) For tail wheel type airplanes, an attitude in which the main and tail

wheels contact the ground simultaneously.

(2) For nose wheel type airplanes, a stalling attitude, or at the maximum angle permitting all parts of the airplane to clear the ground, whichever is lesser.

(b) For both tail and nose wheel type airplanes, all ground reactions must be assumed to be vertical, with the wheels up to speed before the maximum vertical load is attained.

[Revision note: Based on § 3.246]

§ 23.389 One wheel landing.

One side of the main gear is assumed to contact the ground while the airplane is in a level attitude. The ground reactions must be the same as those obtained in accordance with § 23.385 on that side in the level attitude.

[Revision note: Based on § 3.247]

GROUND ROLL CONDITIONS

§ 23.399 Braked roll.

In the braked roll condition, the following applies:

(a) The limit vertical load factor must be 1.33.

(b) The attitudes and ground contacts must be those described in § 23.385 for level landings, with the shock absorbers and tires deflected to their static positions.

(c) A drag reaction equal to the vertical reaction at the wheel multiplied by a coefficient of friction of 0.8 must be applied at the ground contact point of each wheel having brakes, except that the drag reaction need not exceed the maximum value based on limiting brake torque.

[Revision note: Based on § 3.248]

§ 23.401 Side load.

In the side load condition, the following applies:

(a) The airplane must be in a level attitude with only the main wheels contacting the ground and with the shock absorbers and tires deflected to their static positions.

(b) The limit vertical load factor must be 1.33, with the vertical ground reaction divided equally between the main wheels.

(c) The limit side inertia factor must be 0.83, with the side ground reaction divided between the main wheels so that—

(1) 0.5(W) is acting inboard on one side; and

(2) 0.33(W) is acting outboard on the other side.

[Revision note: Based on § 3.249]

TAIL WHEELS

§ 23.411 Supplementary conditions for tail wheels.

In determining the ground loads on the tail wheel and affected supporting structures, the following conditions must be met:

(a) For the obstruction load, the limit ground reaction obtained in the tail down landing condition must be assumed to act up and aft through the axle at 45 degrees. The shock absorber and tire may be assumed to be deflected to their static positions.

(b) For the side load, a limit vertical ground reaction equal to the static load on the tail wheel, in combination with a side component of equal magnitude, must be assumed. If a swivel is used, the tail wheel must be assumed to be swiveled 90 degrees to the airplane longitudinal axis with the resultant ground load passing through the axle. If a lock steering device or shimmy damper is used, the tail wheel must also be assumed to be in the trailing position with the side load acting at the ground contact point. The shock absorber and tire must be assumed to be deflected to their static positions.

[Revision note: Combines §§ 3.250, 3.251, and 3.252]

NOSE WHEELS

§ 23.421 Supplementary conditions for nose wheels.

In determining the ground loads on nose wheels and affected supporting structures, and assuming that the shock absorbers and tires are deflected to their static positions, the following conditions must be met:

(a) For aft loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A drag component of 0.8 times the vertical load.

(b) For forward loads, the limit force components at the axle must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A forward component of 0.4 times the vertical load.

(c) For side loads, the limit force components at ground contact must be—

(1) A vertical component of 2.25 times the static load on the wheel; and

(2) A side component of 0.7 times the vertical load.

[Revision note: Combines §§ 3.253 through 3.256]

SKIPLANES

§ 23.431 Supplementary conditions for skiplanes.

In determining ground loads on skiplanes, and assuming that the airplane is resting on the ground with one main ski frozen at rest and the other main ski and the tail ski free to slide, a limit side force equal to $P/3$ must be applied at the most convenient point near the tail assembly with—

(a) P being the static ground reaction on the tail ski; and

(b) A factor of safety equal to 1.0.

[Revision note: Based on § 3.257]

WATER LOADS

§ 23.441 Water load conditions.

(a) The structure of boat and float type seaplanes must be designed for water loads developed during takeoff and landing with the seaplane in any attitude likely to occur in normal operation at appropriate forward and sinking velocities under the most severe sea conditions likely to be encountered. Unless the applicant makes a rational analysis of the water loads, §§ ——— through ——— (present §§ 4b.251 through 4b.258) apply.

(b) Floats certificated under Part 4a before November 9, 1945, may be installed on airplanes that are designed in accordance with this part.

(c) The requirements set forth in ANC–3 may be used instead of those of paragraph (a) of this section.

[Revision note: Combines §§ 3.265, 3.265–1 (a), and 3.265–2]

FATIGUE EVALUATION

§ 23.451 Pressurized cabins.

The strength, detail design, and fabrication of the pressure cabin structure must be evaluated in accordance with either of the following:

(a) Fatigue strength investigation, in which the structure is shown by analysis, tests, or both to be able to withstand the repeated loads of variable magnitude expected in service.

(b) Fail safe strength investigation, in which it is shown by analysis, tests, or both that catastrophic failure of the structure is not probable after fatigue failure or obvious partial failure of a principal structural element, and that the remaining structures are able to withstand a static ultimate load factor of 75 percent of the limit load factor at V_C, considering the combined effects of normal operating pressures, expected external aerodynamic pressures, and flight loads. These loads must be multiplied by a factor of 1.15 unless the dynamic effects of failure under static load are otherwise considered.

[Revision note: Based on § 3.270]

Subpart D—Design and Construction

§ 23.471 General.

The suitability of all questionable design details or parts that have an important bearing on safety in operations, must be established by tests.

[Revision note: Based on § 3.291]

§ 23.473 Materials and workmanship.

The suitability and durability of materials used in the airplane structure must be established on the basis of experience or tests. The materials used in the airplane structure must conform to approved specifications that insure that they have the strength and other properties assumed in the design data. Workmanship must be of a high standard.

[Revision note: Based on § 3.292]

§ 23.475 Fabrication methods.

The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to attain this objective, the process must be performed in accordance with an approved process specification.

[Revision note: Based on § 3.293]

§ 23.477 Standard fastenings.

Only approved bolts, pins, screws, and rivets may be used in the structure. Approved locking devices and methods must be used for all of those bolts, pins, and screws. No self-locking nuts may be

used on bolts subject to rotation during the operation of the airplane.

[Revision note: Based on § 3.294]

§ 23.479 Protection against deterioration.

Each member of the structure must be suitably protected against deterioration or loss of strength in service due to weathering, corrosion, abrasion, or other causes. In seaplanes, special precautions must be taken against corrosion from salt water, particularly where dissimilar metals are in close proximity. Adequate provisions for ventilation and drainage of all parts of the structure must be made.

[Revision note: Based on § 3.295]

§ 23.481 Inspection provisions.

There must be adequate means to permit the close examination of all parts requiring recurring inspection, adjustments for proper alignment and function, and lubrication.

[Revision note: Based on § 3.296]

STRUCTURAL PARTS

§ 23.491 Material strength properties and design values.

(a) Material strength properties must be based on the number of tests of material conforming to specifications necessary to establish design values on a statistical basis. The design values must be chosen so that the probability of any structure being understrength because of material variations is extremely remote.

(b) Values contained in MIL–HDBK–5, "Metallic Materials and Elements for Flight Vehicle Structure", MIL–HDBK–17, "Plastics for Flight Vehicles, Part I—Reinforced Plastics", ANC–17, "Plastics for Aircraft, Part II—Transparent Glazing Materials", ANC–18 "Design of Wood Aircraft Structures", MIL–HDBK–23, "Composite Construction for Flight Vehicles, Part I—Fabrication Inspection Durability and Repair", and ANC–23, "Sandwich Construction for Aircraft, Part II—Material Properties and Design Criteria" must be used unless they are shown to be inapplicable. These manuals may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20401.

[Revision Note: Based on § 3.301 and note]

§ 23.493 Design properties.

(a) Design properties outlined in chapter 3 of MIL–HDBK–5, may be used subject to the following conditions:

(1) Where applied loads are eventually distributed through single members within an assembly, the failure of which would result in the loss of the structural integrity of the component involved, the guaranteed minimum design mechanical properties listed in MIL–HDBK–5 must be met. Examples of these items are: wing lift struts; spars in two-spar wings; sparcaps in regions such as wing cutouts and wing center sections where loads are transmitted through caps only; and primary attachment fittings dependent on single bolts for load transfer.

(2) Redundant structures in which the partial failure of individual elements would result in applied loads being safely distributed to other load carrying members may be designed on the basis of the "90 percent probability" allowable. Examples of these items are sheet-stiffener combinations and multirivet or multiple bolt connections.

(b) Design values greater than the guaranteed minimums required by paragraph (a) of this section may be used if a "premium selection" of the material is made in which a specimen of each individual item is tested before its use, to determine that the actual strength properties of that particular item will equal or exceed those used in design.

(c) Material correction factors for structural items such as sheets, sheet-stringer combinations, and riveted joints, may be omitted if sufficient test data are obtained to allow a probability analysis showing that 90 percent or more of the elements will either equal or exceed selected design allowable values.

[Revision note: Based on § 3.301–1 (less (b) (1st sentence))]

§ 23.495 Interchangeability of seam-welded and seamless steel tubing.

Seam-welded and seamless steel tubing may be interchanged as follows:

(a) SAE 4130 welded tubing conforming to Specification MIL–T–6731 and SAE 4130 seamless tubing conforming to Specification MIL–T–6736.

(b) SAE 1025 welded tubing and SAE 1025 seamless tubing conforming to Specification MIL–T–5066.

(c) SAE 8630 welded tubing conforming to Specification MIL–T–6734 and SAE 8630 seamless tubing conforming to Specification MIL–T–6732.

[Revision note: Based on § 3.301–2]

§ 23.497 Special factors.

If there is uncertainty concerning the actual strength of a part of the structure, or if the strength is likely to deteriorate in service before normal replacement, increased factors of safety must be used to insure that the reliability of that part is not less than that of the rest of the structure as specified in §§ 23.499 through 23.505.

[Revision note: Based on § 3.302]

§ 23.499 Variability factor.

For parts whose strength is subject to appreciable variability due to uncertainties in manufacturing processes and inspection methods, the factor of safety must be increased so that the probability of any part being under-strength from these causes is extremely remote. Minimum variability factors are set forth in §§ 23.501 through 23.505. Only the highest pertinent variability factor need be considered.

[Revision note: Based on § 3.303]

§ 23.501 Casting factors.

(a) For structural castings, the factor of safety prescribed in § 23.219 must be multiplied by the casting factors specified in paragraphs (b) and (c) of this section. The prescribed tests and inspections are in addition to those necessary to establish foundry quality control. Castings must be inspected in accordance with approved specifications.

(b) Each casting whose failure would preclude continued safe flight and land-of the airplane, or result in serious injury to occupants, must have a casting factor of at least 1.25 and must receive 100 percent inspection by visual, radiographic, and magnetic particle or penetrant inspection methods, or by approved equivalent nondestructive inspection methods. Where such castings have a casting factor less than 1.50, three sample castings must be static tested. The test castings must conform to the strength requirements of § 23.221 at an ultimate load corresponding to a casting factor of 1.25, and must conform to the deformation requirements at a load equal to 1.15 times the limit load. Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.

(c) For structural castings other than those specified in paragraph (b) of this section, the casting factors and inspections must conform to the following table. However, the percentage of castings inspected by nonvisual methods may be reduced when an approved quality control procedure is established. A casting factor of 1.0 may be used for castings procured in accordance with a specification which guarantees the mechanical properties of the material in the castings and provides for demonstation of these properties by test of coupons cut from castings on a sampling basis. The inspection requirements for these castings must be in accordance with the requirements in the following table for casting factors of 1.25 to 1.50, and the testing requirements must be in accordance with paragraph (b) of this section.

Casting factor	*Inspections*
2.0 or greater	100 percent visual.
Less than 2.0 and greater than 1.5.	100 percent visual, magmagnetic particle or penetrant or equivalent nondestructive inspection methods.
1.25 to 1.50	100 percent visual, and netic particle or penetrant, and radiographic or approved equivalent nondestructive inspection methods.

(d) No casting factor need exceed 1.25 with regard to bearing stresses regardless of the method of inspection employed. No casting factor need be used with respect to the bearing surface of a part if the bearing factor used is greater than the casting factor.

(e) Unless they support airplane structural loads, this section does not apply to casting that are pressure tested as parts of a hydraulic or fluid system.

[Revision note: Based on § 3.304]

§ 23.503 Bearing factor.

(a) The factor of safety in bearings at bolted or pinned joints must be increased to provide for—

(1) Relative motion in operation; and

(2) Joints with clearance (free fit) subject to pounding or vibration.

(b) No bearing factor need be applied if other special factors apply.

[Revision note: Based on § 3.306]

§ 23.505 Fitting factor.

A multiplying factor of safety of at least 1.15 must be used in the analysis of all fittings, the strength of which is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and the surrounding structures. This factor applies to all parts of the fitting, the means of attachment, and the bearing areas of the joined members. For integral fittings, the part must be treated as a fitting up to the point where the section properties become typical of the member. No fitting factor need be applied if a type of joint design, based on comprehensive test data, is used. Examples of these joints are continuous joints in metal plating, welded joints, and scarf joints in wood, all made in accordance with approved practices.

[Revision note: Based on § 3.306]

§ 23.507 Fatigue strength.

The structure must be designated, as far as practicable, to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service.

[Revision note: Based on § 3.307]

FLUTTER AND VIBRATION

§ 23.525 Flutter and vibration prevention measures.

(a) The wings, tail, and control surfaces, must be free from flutter, airfoil divergence, and control reversal from lack of rigidity, for all conditions of operation within the limit V–n envelope. In addition—

(1) Adequate wing tortional rigidity must be demonstrated by tests or other approved methods;

(2) The mass balance of surfaces must be designed to prevent flutter; and

(3) The natural frequencies of all main structural components must be determined by vibration tests or other approved methods.

(b) Flight flutter tests are acceptable as proof of freedom from flutter if it is shown by these tests that proper and adequate attempts to induce flutter have been made within the speed range up to V_D, and that the vibratory response of the structure during the test indicates freedom from flutter.

[Revision note: Combines §§ 3.311 and 3.311–2(a)]

WINGS

§ 23.535 Proof of strength.

The strength of stressed-skin wings must be proven by load tests or by combined structural analysis and load tests.

[Revision note: Based on § 3.317]

§ 23.537 Rib tests.

Rib tests must simulate the effects of—

(a) The tortional rigidity of spars;
(b) Fixity conditions;
(c) Lateral supports;
(d) Attachment to spars;
(e) Ailerons; and
(f) High lift devices.

[Revision note: Based on § 3.318]

CONTROL SURFACES (FIXED AND MOVABLE)

§ 23.547 Proof of strength.

Limit load tests of control surfaces are required. These tests must include the horn or fitting to which the control system is attached. Instructural analyses, rigging loads due to wire bracing must be accounted for in a rational or conservative manner.

[Revision note: Based on § 3.327]

§ 23.549 Installation.

Movable tail surfaces must be installed so that there is no interference between the surfaces or their bracing when each surface is held in its extreme position and all others are operated through their full angular movement. If an adjustable stabilizer is used, it must have stops that, in the event of failure of the adjusting mechanism, will limit its travel to a range permitting safe flight and landing.

[Revision note: Based on § 3.328]

§ 23.551 Hinges.

Each control surface hinge, except those incorporating ball and roller bearings, must have a factor of safety of not less than 6.67 with respect to the ultimate bearing strength of the softest material used as a bearing. For hinges incorporating ball or roller bearings, the approved rating of the bearing may not be exceeded. Hinges must have sufficient strength and rigidity for loads parallel to the hinge line.

[Revision note: Based on § 3.329]

§ 23.553 Mass balance weights.

The supporting structure and the attachment of concentrated mass balance weights used on control surfaces must be designed for the following limit acceleration: 24g normal to the plane of the control surface; 12g fore and aft; and 12g parallel to the hinge line.

[Revision note: Based on § 3.330]

CONTROL SYSTEMS

§ 23.563 General.

Each control must operate easily, smoothly, and positive enough to allow proper performance of its functions. Controls must be arranged and identified to provide for convenience in operation and to prevent the possibility of confusion and subsequent inadvertent operation.

[Revision note: Based on § 3.335]

§ 23.565 Primary flight controls.

(a) Primary flight controls are those used by the pilot for the immediate control of pitch, roll, and yaw.

(b) The design of two-control airplanes must minimize the likelihood of complete loss of lateral or directional control in the event of failure of any connecting or transmitting element in the control system.

[Revision note: Based on § 3.336]

§ 23.567 Trimming controls.

(a) Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation. There must be means adjacent to the trim control to indicate to the pilot the direction of trim control movement relative to airplane motion. In addition, there must be means to indicate to the pilot the position of the trim device with respect to the range of adjustment. This latter means must be visible to the pilot and must be located and designed so as to prevent confusion.

(b) Trimming devices must be designed so that, when any one connecting or transmitting element in the primary flight control system fails, normal trimming operation may be continued with—

(1) For single-engine airplanes, the longitudinal trimming devices; or

(2) For multiengine airplanes, the longitudinal and directional trimming devices.

(c) Tab controls must be irreversible unless the tab is properly balanced and has no unsafe flutter characteristics. Irreversible tab systems must have adequate rigidity and reliability in the portion of the system from the tab to the attachment of the irreversible unit to the airplane structure.

[Revision note: Based on § 3.337]

§ 23.569 Wing flap controls.

Each control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of this part is based, the flap will not move from that position unless the control is adjusted or it is moved by the automatic operation of a flap load limiting device. There must be means to indicate the flap position to the pilot. If any flap position other than retracted or fully extended is used to show compliance with the performance requirements of this part, there must be means to indicate these positions. The rate of movement of the flaps in response to the operation of the pilot's control or automatic device may not result in unsatisfactory flight or performance characteristics under steady or changing conditions of airspeed, engine power, and attitude.

[Revision note: Based on § 3.338]

§ 23.571 Wing flap position indicators.

(a) For flap installations with only the retracted and fully extended positions, an indicator is required unless—

(1) A direct operating mechanism provides a sense of "feel" and position (such as when a mechanical linkage is employed); or

(2) The flap position is readily determined without seriously detracting from other piloting duties under all conditions of flight, either day or night.

(b) For flap installations with intermediate flap positions, an indicator is required unless the installation complies with paragraph (a) (1) of this section.

[Revision note: Based on § 3.338–1]

§ 23.573 Flap interconnection.

(a) The motion of flaps on opposite sides of the plane of symmetry must be synchronized by a mechanical interconnection, unless it is shown that the airplane has safe flight characteristics

while the flaps are retracted on one side and extended on the other.

(b) Where an interconnection is used in multiengine airplanes, it must be designed to account for the unsymmetrical loads resulting from flight with the engine or engines on one side of the plane of symmetry inoperative and the remaining engine or engines at takeoff power. For single-engine airplanes, it may be assumed that 100 percent of the critical air load acts on one side and 70 percent on the other.

[Revision note: Based on § 3.339]

§ 23.575 Stops.

Each control system must have stops that positively limit the range of motion of the control surfaces. Stops must be located in the system so that wear, slackness, or take-up adjustments will not appreciably affect the range of surface travel. The stops must be able to withstand the loads corresponding to the design conditions for the control system.

[Revision note: Based on § 3.340]

§ 23.577 Control system locks.

Any control system locking device must be installed to provide unmistakable warning to the pilot when it is engaged. There must be means to prevent locks from becoming engaged in flight.

[Revision note: Based on § 3.341]

§ 23.579 Proof of strength.

Compliance with limit load requirements must be proven by tests. The direction of test loads must produce the most severe loading of the control system structure. The testing must include all fittings, pulleys, and brackets used to attach the control system to the primary structure. Analyses or individual load tests must be made to show compliance with the multiplying factor of safety requirements specified for control system joints subjected to angular motion.

[Revision note: Based on § 3.342]

§ 23.581 Operation test.

Operation tests must be made by operating the controls from the pilot compartment with the entire system loaded in a manner corresponding to the limit air loads on the surface. For secondary control systems, including adjustable stabilizers, the system loading in the operation tests need not exceed that corresponding to the maximum pilot effort established in accordance with § 23.363. In this test there may be no jamming, excessive friction, or excessive deflection.

[Revision note: Based on § 3.343]

CONTROL SYSTEM DETAILS

§ 23.591 General.

Each control system and operating device must be designed and installed in a manner that will prevent jamming, chafing, or interference, resulting from inadequate clearances or from cargo, passengers, or loose objects. Special precautions must be taken in the cockpit to prevent foreign objects from jamming the controls. Provision must be made to prevent the slapping of cables or tubes against parts of the airplane. The elements of the flight control system must have design features or must be distinctively and permanently marked to minimize the possibility of incorrect assembly which could result in malfunctioning of the control system.

[Revision note: Based on § 3.344]

§ 23.593 Cable systems.

(a) Each cable, cable fitting, turnbuckle, splice, and pulley used in the airplane must conform to approved specifications. No cable smaller than $\frac{1}{8}$-inch diameter may be used in primary control systems. Cable systems must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations. Provision for visual inspection must be made at all fairleads, pulleys, terminals, and turnbuckles.

(b) Each pulley type and size must correspond to the cable with which it is used, as specified in the pulley specification. Each pulley must have satisfactory guards which are closely fitted to prevent the cable from becoming misplaced or fouled, even when slack. The pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

(c) Fairleads must be installed so that they do not cause a change in cable direction of more than three degrees. Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.

(d) Turnbuckles must be attached to parts with angular motion in a manner that will positively prevent binding throughout the range of travel.

(e) Tab control cables are not part of the primary control system. Therefore, the cable diameter requirement of paragraph (a) of this section does not apply to tab control cables with high strength margins. However, where the airplane would not be safely controllable in flight and landing with tabs in the most adverse positions required for the various critical trim, weight, and center of gravity conditions, the tab systems must be designed in a manner that will provide reliability equivalent to that required for primary systems.

[Revision note: Combines §§ 3.345 and 3.345–1]

§ 23.595 Joints.

Each control system joint that is subject to angular motion in push-pull systems, except a ball and roller bearing system, must incorporate a factor of safety of at least 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for those joints in cable control systems. For ball or roller bearings, the approved rating of the bearing may not be exceeded.

[Revision note: Based on § 3.346]

§ 23.597 Spring devices.

The reliability of any spring device used in the control system must be established by tests simulating service conditions, unless it is shown that failure of the spring will not cause flutter or unsafe flight characteristics.

[Revision note: Based on § 3.347]

LANDING GEAR

SHOCK ABSORBERS

§ 23.607 Tests.

The shock absorbing elements in the main, nose, and tail wheel units of the airplane must be substantiated by the tests specified in § 23.609. The shock absorbing ability of the landing gear during taxiing must be shown in the operational tests required by § 23.185.

[Revision note: Based on § 3.351]

§ 23.609 Shock absorption tests.

(a) It must be shown by energy absorption tests that the limit load factors selected for design in accordance with § 23.373 will not be exceeded in landings with the limit descent velocity specified in that section.

(b) In addition, it must be shown that, when the descent velocity is at least 1.2 times the limit descent velocity, there is a reserve of energy absorption ability. In this test there may be no failure of the shock absorbing unit, although yielding of the unit is allowed. Wing lift equal to the weight of the airplane may be assumed.

[Revision note: Based on § 3.352]

§ 23.611 Limit drop tests.

(a) If compliance with § 23.609(a) is shown by free drop tests, these tests must be made on the complete airplane, or on units consisting of wheel, tire, and shock absorber, in their proper relation, from free drop heights not less than those determined by the following formula:

$$h \text{ (inches)} = 3.6\ (W/S)^{1/2}$$

However, the free drop height may not be less than 9.2 inches and need not be greater than 18.7 inches.

(b) In simulating the permissible wing lift in free drop tests, the landing gear unit must be dropped with an effective weight determined from the following formula:

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]$$

where—

W_e = the effective weight to be used in the drop test;

h = specified height of drop in inches;

d = deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass. (The value of d used in the computation of W_e may not exceed the value actually obtained in the drop tests);

$W = W_M$ for main gear units, and must be equal to the static weight on the particular unit with the airplane in the level attitude (with the nose wheel clear, in the case of nose wheel type airplanes);

$W = W_T$ for tail gear units, and must be equal to the static weight on the tail unit with the airplane in the tail down attitude;

$W = W_N$ for nose wheel units, and must be equal to the static reaction which will exist at the nose wheel when the mass of the airplane is concentrated at the center of gravity and exerts a force of $1.0g$ downward and $0.33g$ forward; and

L = ratio of assumed wing lift to airplane weight, but may not be greater than 0.667.

(c) The attitude in which the landing gear unit is drop tested must simulate the airplane landing condition resulting in critical energy absorption for that unit.

[Revision note: Based on § 3.353]

§ 23.613 Limit load factor determination.

(a) The limit inertia load factor must be determined from the drop test specified in § 23.611 according to the following formula:

$$n = n_j \frac{W_e}{W} + L$$

where—

n_j = the load factor developed in the drop test (that is, the acceleration (dv/dt) in g's recorded in the drop test) plus 1.0.

(b) The value of n determined in accordance with paragraph (a) may not be greater than the limit inertia load factor used in the landing conditions in § 23.373.

[Revision note: Based on § 3.354]

§ 23.615 Reserve energy absorption drop tests.

If compliance with the reserve energy absorption condition under § 23.609(b) is shown by free drop tests, the drop height may not be less than 1.44 times the drop height specified in § 23.611. In simulating wing lift equal to the airplane weight, the units must be dropped with an effective weight equal to

$$W_e = W \frac{h}{h+d}$$

where the symbols and other details are the same as the corresponding ones in § 23.611.

[Revision note: Based on § 3.355]

RETRACTING MECHANISM

§ 23.625 General.

Each landing gear retracting mechanism and its supporting structure must be designed for maximum flight load factors with the gear retracted and must also be designed for the combination of friction, inertia, brake torque, and air loads, occuring during retraction at any airspeed up to 1.6 V_{S_1} with flaps retracted, and for any load factor up to those specified in § 23.265, for the flaps-extended condition. The landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads with the landing gear extended at any speed up to at least 1.6 V_{S_1} with flaps retracted. There must be positive mechanical means to keep the wheels in the extended position.

[Revision note: Combines §§ 3.356 and 3.356-1(b) (last sentence)]

§ 23.627 Emergency operation.

Except for amphibians, an airplane not having manually operated landing gear must have an auxiliary means of extending that landing gear.

[Revision note: Based on § 3.357]

§ 23.629 Operation test.

The proper functioning of the landing gear retraction mechanism must be shown by operational tests.

[Revision note: Based on § 3.358]

§ 23.631 Position indicator and warning device.

If retractable landing wheels are used, there must be means to indicate to the pilot when the wheels are secured in the extreme positions. In addition, landplanes must have an aural or equally effective warning device which functions continuously, when one or more throttles are closed, until the gear is down and locked. A throttle stop is not an acceptable alternative to an aural landing gear warning device.

[Revision note: Based on § 3.359 and last sentence of note]

WHEELS AND TIRES

§ 23.643 Wheels.

Only approved main and nose wheels may be used. The maximum static load rating of each wheel may not be less than the corresponding static ground reaction under the design maximum weight and critical center of gravity. The maximum limit load rating of each wheel must be at least the maximum radial limit load determined from the applicable ground load requirements of this part.

[Revision note: Based on § 3.361]

§ 23.645 Tires.

(a) Landing gear wheels may be equipped with any tire that properly fits the rim of the wheel, if the tire rating (assigned by the Tire and Rim Association or the Administrator) is not exceeded—

(1) By a load on each main wheel tire equal to the corresponding static ground reaction under the design maximum weight and critical center of gravity; and

(2) By a load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel, assuming the mass of the airplane to be concentrated at the most critical center of gravity and exerting a force of 1.0g downward and 0.31g forward, with the reactions distributed to the nose and main wheels by the principles of statics, and with the drag reaction at the ground applied only at those wheels having brakes.

(b) If specially constructed tires are used, the wheels must be plainly and conspicuously marked to that effect. The markings must include the make, size, number of plies, and identification marking of the proper tire.

[Revision note: Combines §§ 3.362 and 3.362-1]

BRAKES

§ 23.655 Brakes.

The airplane must have brakes that are adequate to prevent the airplane from rolling on a paved runway while applying takeoff power to the critical engine, and of enough capacity to provide adequate speed control during taxiing without excessive pilot loads.

[Revision note: Based on § 3.363]

SKIS

§ 23.665 Skis.

Skis must be of an approved type. The maximum limit load rating of each ski may not be less than the maximum limit load determined in accordance with the applicable ground load requirements of this part.

[Revision note: Based on § 3.364]

HULLS AND FLOATS

§ 23.675 Seaplane main floats.

(a) Each seaplane main float must be of an approved type and must conform to the provisions of § 23.441. In addition, each seaplane main float must—

(1) Have a buoyancy of 80 percent in excess of that required to support the maximum weight of the seaplane in fresh water; and

(2) Have enough watertight compartments to provide reasonable assurance that the airplane will stay afloat if any two compartments of the main floats are flooded.

(b) Each main float must contain at least four watertight compartments of approximately equal volume.

[Revision note: Based on § 3.371]

§ 23.677 Hulls of boat type seaplanes and amphibians.

(a) The hull of a boat type seaplane (or amphibian) of 1,500 pounds or more maximum certificated weight must have watertight compartments designed and arranged so that the hull, auxiliary floats, and tires (if used), will keep the airplane (at the maximum certificated weight) afloat in fresh water when—

(1) In the case of an airplane of 5,000 lbs. or more maximum certificated weight, any two adjacent compartments are flooded; and

(2) In the case of an airplane of 1,500 pounds up to but not including 5,000 pounds maximum certificated weight, any one compartment is flooded.

(b) The hulls of boat type seaplanes (or amphibians) with less than 1,500 pounds maximum certificated weight need not be compartmented.

(c) Bulkheads (where used) may have watertight doors for communication between compartments.

[Revision note: Based on § 3.372]

§ 23.679 Auxiliary floats.

Auxiliary floats must be arranged so that, when completely submerged in fresh water, they will provide a righting moment that is at least 1.5 times the upsetting moment caused by the airplane being tilted.

[Revision note: Based on § 3.373]

FUSELAGE

PILOT COMPARTMENT

§ 23.689 General.

(a) Each pilot compartment and its equipment must provide a satisfactory

degree of safety and assurance that the pilot will be able to perform all his duties and operate the controls in the correct manner without unreasonable concentration or fatigue.

(b) The primary cockpit controls set forth in § 23.697(b), excluding cables and control rods, must be located with respect to the propellers so that no part of the pilot or the controls lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub and making an angle of 5 degrees forward or aft of the plane of rotation of the propeller.

[Revision note: Based on § 3.381]

§ 23.693 Pilot vision and view.

(a) Each pilot compartment must be free from glare and reflections that could interfere with the pilot's vision, and must be designed so that—

(1) The pilot's view is sufficiently extensive, clear, and undistorted, for safe operation; and

(2) During moderate rain conditions, the pilot has an adequate view of the flight path in normal flight and while landing, and is sufficiently protected from the elements that his vision is not unduly impaired.

(b) For each airplane intended for night operation, compliance with paragraph (a) of this section must be shown in night flight tests.

[Revision note: Based on § 3.382]

§ 23.695 Windshields, windows, and canopies.

(a) Each internal glass pane must be of a nonsplintering, safety type.

(b) The design of windshields, windows, and canopies on pressurized airplanes must be based on factors peculiar to high altitude operation, including at least the effect of continuous and cyclic pressurization loadings, the inherent characteristics of the material used, and the effects of temperatures and temperature gradients.

(c) On pressurized airplanes, an inclosure canopy including a representative part of the installation must be subjected to special tests to account for the combined effects of continuous and cyclic pressurization loadings and flight loads.

(d) The windshield and side windows forward of the pilot's back when he is seated in the normal flight position, must have a luminous transmittance value of not less than 70 percent.

[Revision note: Based on § 3.383 (and note following § 3.383(b))]

§ 23.697 Cockpit controls.

(a) Each cockpit control must be located and (except where its function is obvious) identified to provide for convenience in operation, including provisions to prevent confusion and consequent inadvertent operation. The controls must be located and arranged so that the pilot, when seated, has full and unrestricted movement of each control without interference from either his clothing or the cockpit structure.

(b) Cockpit controls must be designed so that they operate in accordance with the following movement and actuation:

Controls	*Movement and actuation*
Primary:	
Aileron	Right (clockwise) for right wing down.
Elevator	Rearward for nose up.
Rudder	Right pedal forward for nose right.
Powerplant:	
Throttle	Forward to open.

(c) Identical powerplant controls for the engines of multiengine airplanes must be located to prevent confusion as to the engines they control.

(d) The wing flap and auxiliary lift device controls must be located centrally, or to the right of the pedestal or powerplant throttle control centerline, and must be sufficiently displaced from the landing gear control to avoid confusion.

(e) The landing gear control must be located to the left of the throttle centerline or pedestal centerline.

(f) Landing gear and wing flap control knobs must be shaped in accordance with the following figure:

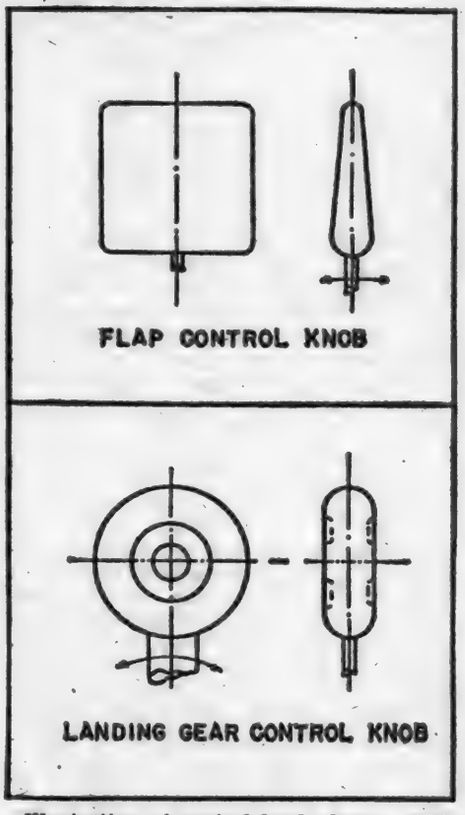


Illustration of control knob shapes. This figure indicates general shape only and is not intended to indicate the exact size or specific proportions of the control knobs.

[Revision note: Combines §§ 3.384 and figures 3-13 and 3-14]

§ 23.699 Instruments and markings.

Instruments must be arranged as prescribed in § 23.1139. Instruments and controls must have operational markings, instructions, and placards, as required by §§ 23.1483 through 23.1509.

[Revision note: Based on § 3.385]

EMERGENCY PROVISIONS

§ 23.709 Protection.

(a) The fuselage must be designed to give reasonable assurance that each occupant, if he makes proper use of belts or harnesses for which provision is made in the design, will not suffer serious injury during minor crash conditions as a result of any vulnerable part of his body contacting any penetrating or relatively solid object, although parts of the airplane may be damaged.

(b) The ultimate accelerations to which occupants are assumed to be subjected are shown on the following table:

ULTIMATE CRASH ACCELERATIONS

	Normal and utility categories	Acrobatic category
Upward	3.0*g*	4.5*g*
Forward	9.0*g*	9.0*g*
Sideward	1.5*g*	1.5*g*

(c) For airplanes with retractable landing gear, the fuselage, in combination with other portions of the structure, must be designed to afford protection to the occupants in a wheels-up landing with moderate descent velocity, assuming a vertical ultimate acceleration of 3*g*'s and a friction coefficient of 0.5 at the ground.

(d) If the characteristics of an airplane make a turnover reasonably probable, the fuselage, in combination with other parts of the structure, must be designed to afford protection to the occupants in a complete turnover, assuming a vertical ultimate acceleration of 3*g*'s and a friction coefficient of 0.5 at the ground.

(e) Except as provided in § 23.727, the means for preventing the breakaway of all items of mass which could injure the occupants if they came loose in a minor crash, and their supporting structures, must be designed for the crash loads specified in paragraph (b) of this section.

[Revision note: Based on § 3.386]

§ 23.711 Emergency exits.

(a) *Number and location.* Emergency exits must be located to allow escape without crowding in all probable crash attitudes. The airplane must have at least the following emergency exits:

(1) For an airplane with a seating capacity of more than five occupants, but less than 16, at least one emergency exit on the opposite side of the cabin from the main door specified in § 23.723.

(2) For an airplane with a seating capacity of more than 15 occupants, the emergency exit specified in subparagraph (1) of this paragraph, and, in addition, an emergency exit in the top or side of the cabin for each seven occupants, or fraction thereof, above 15. However, no more than four exits are required if their arrangement and size allows the quick evacuation of all occupants.

(3) If the pilot compartment is separated from the cabin by a door which is likely to block the pilot's escape in a

minor crash, there must be an exit in the pilot's compartment. The number of exits required by subparagraphs (1) and (2) of this paragraph must then be separately determined for the passenger compartment using the seating capacity of that compartment.

(b) *Type and operation.* Emergency exits must be movable windows, panels, or external doors, that provide a clear and unobstructed opening of a size and shape in which at least a 19-by-26-inch ellipse can be inscribed. In addition, each emergency exit must—

(1) Be readily accessible, requiring no exceptional agility to be used in emergencies;

(2) Have a method of opening that is simple and obvious;

(3) Be arranged and marked for easy location and operation, even in darkness;

(4) Have reasonable provisions against jamming by fuselage deformation; and

(5) In the case of acrobatic category airplanes, allow all occupants to bail out quickly with parachutes at any speed between V_{S_0} and V_D.

(c) *Tests.* The proper functioning of each emergency exit must be demonstrated by tests.

[Revision note: Based on § 3.387]

§ 23.713 Fire precautions.

(a) *Cabin interiors.* Only materials that are flash resistant may be used in cabin interiors. In compartments where smoking is to be permitted, the wall and ceiling linings, covering of all upholstery, floors, and furnishings, must be flame resistant. These compartments must have an adequate number of self-contained ash trays. The other compartments must be placarded against smoking.

(b) *Combustion heaters.* Only approved combustion heaters may be installed. The installation must meet applicable powerplant installation requirements covering fire hazards and precautions. Each applicable requirement concerning fuel tanks, lines, and exhaust systems, must be considered. Each combustion heater must have means to automatically shut off and hold off its ignition and fuel supply when the heat exchanger temperature or ventilating air temperature exceed safe limits or when either the combustion airflow or the ventilating airflow become inadequate for safe operation. This automatic device must be remote from the heater and must be independent of the components provided for the normal continuous control of air temperature, airflow, and fuel flow.

[Revision note: Based on § 3.388]

PERSONNEL AND CARGO ACCOMMODATIONS

§ 23.723 Doors.

Each enclosed cabin with passenger accommodations must have at least one adequate and easily accessible external door. No passenger door may be located with respect to the propeller discs so as to endanger persons using the door.

[Revision note: Based on § 3.389]

§ 23.725 Seats and berths.

Each seat and berth must be of an approved type. Each seat, berth, and its supporting structure, must be designed for occupants weighing at least 170 pounds (or 190 pounds with parachute for seats in airplanes intended for the acrobatic and utility categories), and for the maximum load factors corresponding to all specified flight and ground load conditions including the emergency landing conditions prescribed in § 23.709. In addition, the following requirements must be met:

(a) Each pilot seat must be designed for the reactions resulting from the application of pilot forces to the primary flight controls, as prescribed in § 23.357.

(b) Each seat in utility and acrobatic category airplanes must be designed to accommodate passengers wearing parachutes, unless otherwise placarded.

(c) Each berth installed parallel to the longitudinal axis of an airplane must be designed so that the forward part has a padded end board, canvas diaphragm, or equal means capable of withstanding the static load reaction of the occupant when the occupant is subjected to the forward accelerations prescribed in § 23.709. These berths must have an approved safety belt and may not have corners or other parts likely to cause serious injury to a person occupying the berth during emergency conditions. Safety belt attachments for these berths must be designed to withstand the critical loads resulting from all relevant flight and ground load conditions and from all the emergency landing conditions prescribed in § 23.709, with the exception of the forward load.

(d) In determining the strength of the attachment of the seat and berth to the structure, the accelerations prescribed in § 23.709 must be multiplied by a factor of 1.33 rather than by the fitting factor prescribed in § 23.505.

[Revision note: Combines §§ 3.390 and 3.390–1]

§ 23.727 Cargo compartments.

Each cargo compartment must be designed for the placarded maximum weight of contents and critical load distributions at the appropriate maximum load factors corresponding to all specified flight and ground load conditions of this part. Suitable provision must be made to prevent the dangerous shifting of the contents of cargo compartments, and adequate to protect the passengers from injury by the contents of any cargo compartment under any forward acting accelerating force up to 4.5 *g*'s.

[Revision note: Based on § 3.392]

§ 23.729 Ventilation.

Each passenger and crew compartment must be suitably ventilated. Carbon monoxide concentration may not exceed 1 part in 20,000 parts of air.

[Revision note: Based on § 3.393]

PRESSURIZED CABINS

§ 23.739 Pressure control.

For a pressurized cabin, at least the following valves, controls, and indicators for controlling cabin pressure must be provided:

(a) Two pressure relief valves (at least one of which is the normal regulating valve) to automatically limit the positive pressure differential to a predetermined value at the maximum rate of flow delivered by the pressure source. The pressure differential is considered to be positive when the internal pressure is greater than the external pressure. The combined capacity of the relief valves must be large enough so that the failure of any one valve will not cause an appreciable rise in the pressure differential.

(b) Two reverse pressure differential relief valves (or their equivalents) to automatically prevent a negative pressure differential from damaging the structure. However, one valve is enough if it is of a design which reasonably prevents malfunctioning.

(c) A means by which the pressure differential can be rapidly eliminated.

(d) An automatic or manual regulator for controlling the intake or exhaust airflow, or both, allowing the required internal pressures and airflow rates to be maintained.

(e) Instruments so show the pilot the pressure differential, the absolute pressure in the cabin, and the rate of change of the absolute pressure.

(f) A warning device to show the pilot when the safe or preset pressure differential and absolute cabin pressure limits are exceeded.

(g) A warning placard for the pilot if the structure is not designed for pressure differentials up to the maximum relief valve setting in combination with landing loads.

(h) A means to stop rotation of the compressor or to divert airflow from the cabin if continued rotation of an engine-driven cabin compressor or continued flow of any compressor bleed air will create a hazard if a malfunction occurs.

[Revision note: Based on § 3.395]

§ 23.741 Pressurization tests.

(a) *Strength test.* The complete pressurized cabin, including its doors, windows, canopy, and valves, must be tested as a pressure vessel for the pressure differential specified in § 23.291(c).

(b) *Functional tests.* The following functional tests must be performed:

(1) Tests of the functioning and capacity of the positive and negative pressure differential valves and of the emergency release valve, to simulate the effects of closed regulator valves.

(2) Tests of each part of the pressurization system to show proper functioning under all possible conditions of pressure, temperature, and moisture, up to the maximum altitude selected for certification.

(3) Flight tests to demonstrate the performance of the pressure supply, pressure and flow regulators, indicators, and warning signals, in steady and stepped climbs and descents at rates corresponding to the maximum attainable within the operating limitations of the airplane up to the maximum altitude selected for certification.

(4) Tests of each door or emergency exit to show that it operates properly

after being subjected to the flight tests prescribed in subparagraph (3) of his paragraph.

[Revision note: Based on § 3.396]

MISCELLANEOUS

§ 23.751 Leveling marks.

The airplane must have leveling marks for the purpose of leveling the airplane on the ground.

[Revision note: Based on § 3.401]

Subpart E—Powerplant

GENERAL

§ 23.771 Components.

(a) The powerplant installation of an airplane includes all components that are necessary for propulsion and all components that affect the safe operation and control of the major propulsive units. "Components" of a powerplant installation means the elements of that installation that are furnished by the airplane, engine, or propeller manufacturer, including components of the fuel system that are integral parts of the type certificated engine.

(b) Each powerplant installation must be designed and built to assure the safe operation of the airplane.

(c) Each powerplant installation must be accessible for all necessary inspections and maintenance.

[Revision note: Combines §§ 3.411 and 3.411–1]

ENGINES AND PROPELLERS

Each engine must have been certificated under Part 33 [New] (present Part 13) of this subchapter.

[Revision note: Based on § 3.415]

§ 23.783 Propellers.

(a) Each propeller must have been certificated under Part 35 [New] (present Part 14) of this subchapter.

(b) Engine power and propeller shaft rotational speed allowed for use in the airplane may not exceed the limits for which the propeller has been certificated.

(c) Each propeller that may be feathered in flight must have a means to unfeather it in flight.

[Revision note: Based on § 3.416]

§ 23.785 Propeller vibration.

(a) Each propeller with metal blades, or highly stressed metal components, must be shown to have vibration stresses in all normal operating conditions that do not exceed those that have been shown by the propeller manufacturer to be safe for continuous operation. This must be shown by actual measurement of stresses through direct testing of the propeller, or by comparison with similar installations that have been so tested. The Administrator may accept other test methods or service experience, that prove the safety of the installation.

(b) The Administrator may require proof of safe vibration characteristics for any type of propeller, except for conventional, fixed-pitch, wood propellers.

[Revision note: Based on § 3.417]

§ 23.787 Propeller pitch and speed limitations.

The propeller pitch and speed must be limited to values that will assure safe operation under all normal conditions of operation.

[Revision note: Based on § 3.418]

§ 23.789 Speed limitations for propellers that cannot be controlled in flight.

(a) During takeoff and initial climb at best rate of climb speed, each propeller, the pitch of which cannot be controlled in flight, must have a means to limit the engine r.p.m., at full throttle or at maximum allowable takeoff manifold pressure, to a speed not greater than the maximum allowable takeoff r.p.m.

(b) During a closed throttle glide at the placarded "never-exceed speed", the propeller may not cause the engine to rotate at a speed in excess of 110 percent of its maximum allowable continuous speed.

(c) Except as provided in § 23.73(b), each airplane of more than 6,000 lbs. maximum weight may not use a propeller pitch setting less than that allowed by paragraph (a) of this section to obtain takeoff r.p.m. at the best angle of climb speed to show compliance with paragraphs (a) and (d) of § 23.73.

[Revision note: Combines §§ 3.419 and 3.419–1(a) (2d sentence)]

§ 23.791 Speed and pitch limitations for controllable pitch propellers without constant speed controls.

Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that—

(a) The lowest possible pitch allows compliance with § 23.789(a); and

(b) The highest possible pitch allows compliance with § 23.789(b).

[Revision note: Based on § 3.420]

§ 23.793 Variable pitch propellers with constant speed controls.

Each variable pitch propeller with constant speed controls must have—

(a) With the governor in operation, a means at the governor to limit the maximum engine speed to the maximum permissible takeoff r.p.m.; and

(b) With the governor inoperative, a means to limit the maximum engine speed to 103 percent of the maximum permissible takeoff r.p.m. with the propeller blades at the lowest possible pitch and with takeoff manifold pressure, the airplane stationary, and no wind.

[Revision note: Based on § 3.421]

§ 23.795 Propeller clearance.

Unless smaller clearances are properly substantiated, propeller clearances with the airplane at maximum certificated weight, with the most adverse center of gravity, and with the propeller in the most adverse pitch position, may not be less than the following:

(a) *Ground clearance.* There must be a clearance of at least seven inches (for each airplane with nose wheel type landing gear) or nine inches (for each airplane with tail wheel type landing gear) with the landing gear statically deflected and the airplane in the level, normal takeoff, or taxiing attitude, whichever is most critical. In addition, for each airplane with conventional landing gear struts using fluid or mechanical means for absorbing landing shocks, there must be positive clearance between the propeller and the ground when the airplane is in the level takeoff attitude, the critical tire completely deflated, and the corresponding landing gear strut bottomed.

(b) *Water clearance.* There must be a clearance of at least 18 inches between each propeller and the water, unless compliance with § 23.187 can be demonstrated with a lesser clearance.

(c) *Structural clearance.*

(1) There must be at least one inch radial clearance between the blade tips and the airplane structure, or whatever additional radial clearance is necessary to prevent harmful vibration.

(2) There must be a minimum clearance of one-half inch longitudinal clearance between the propeller blades or cuffs and stationary parts of the airplane. There must be adequate clearance between other rotating parts of the propeller or spinner and stationary parts of the airplane.

[Revision note: Combines §§ 3.422 and 3.422–2 (1st sentence)]

FUEL SYSTEM

§ 23.805 General.

The fuel system must be constructed and arranged so that fuel flows to each engine at a rate and pressure adequate for proper engine functioning under all normal conditions of operation.

[Revision note: Based on § 3.429]

ARRANGEMENT

§ 23.807 Fuel system arrangement.

Each fuel system must be arranged to permit a fuel pump to draw fuel from only one tank at a time. Each gravity feed system may not supply fuel to an engine from more than one tank at a time, unless the tank air spaces are interconnected so that all interconnected tanks will feed equally.

[Revision note: Based on § 3.430]

§ 23.809 Multiengine fuel system arrangement.

(a) Each fuel system of a multiengine airplane must be arranged so that, in at least one system configuration, the failure of any one component (other than a fuel tank) will not result in the loss of power of more than one engine nor require immediate action by the pilot to prevent the loss of power of more than one engine.

(b) Each multiengine airplane using a single fuel tank, or series of fuel tanks interconnected to function as a single fuel tank, must have independent tank outlets to each engine. Each outlet must incorporate a shutoff valve at the tank. This valve may also serve as the firewall

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shutoff valve required by § 23.879 if the line between the valve and the engine compartment does not contain a hazardous amount of fuel than can drain into the engine compartment. In addition, there must be—

(1) At least two vents arranged to minimize the possibility of both vents becoming obstructed simultaneously;

(2) Filler cap(s) designed to minimize the possibility of incorrect installation or loss in flight; and

(3) A fuel system in which each part supplying fuel from the tank outlet to any one engine is entirely independent of each part of the system supplying fuel to any other engine(s).

[Revision note: Based on § 3.431]

OPERATION

§ 23.819 Fuel flow rate.

(a) The ability of the fuel system to provide fuel at the rates specified in §§ 23.821 through 23.827 and at a pressure sufficient for proper carburetor operation must be demonstrated with the airplane in the attitudes which are most critical with respect to fuel feed and quantity of usable fuel. These conditions may be simulated in a suitable mockup.

(b) The amount of fuel in the tank being tested may not exceed the unusable fuel supply for that tank, as determined under § 23.827, plus the additional fuel necessary to conduct the flow test. If there is a fuel flowmeter in the system, it must be blocked during the flow test and the fuel must flow through the meter bypass.

[Revision note: Based on § 3.433]

§ 23.821 Fuel flow rate for gravity systems.

Fuel flow rate for gravity systems (main and reserve supply) must be 150 percent of the actual takeoff fuel consumption of the engine.

[Revision note: Based on § 3.434]

§ 23.823 Fuel flow rate for pump systems.

The fuel flow rate for each pump system (main and reserve supply) must be 0.9 pound per hour for each takeoff horsepower or 125 percent of the actual takeoff fuel consumption of the engine, whichever is greater. This flow rate is required for each primary engine-driven pump and each emergency pump, and must be available when the pump is running as it would during takeoff. For each hand-operated pump, this rate must occur at not more than 60 complete cycles (120 single strokes) per minute.

[Revision note: Based on § 3.435]

§ 23.825 Fuel flow rate for auxiliary fuel systems and fuel transfer systems.

Sections 23.821 and 23.823 apply to each auxiliary and transfer system, except that the required fuel flow rate must be established upon the basis of maximum continuous power and engine rotational speed, instead of takeoff power and fuel consumption. A lesser flow rate may be used for a small auxiliary tank feeding into a large main tank, if there is a suitable placard stating that the auxiliary tank is not to be opened to the main tank unless a predetermined satisfactory amount of fuel remains in the main tank.

[Revision note: Based on § 3.436]

§ 23.827 Determination of unusable fuel supply and fuel system operation on low fuel.

(a) The unusable fuel supply for each tank is the amount at which the first evidence of malfunctioning occurs under the conditions specified in this section. If more than one fuel tank is involved, any tank that is not needed to feed the engine under all conditions specified in this section need be investigated only for the flight conditions in which it is to be used. In such a case, the unusable fuel supply for that tank is based on the most critical applicable conditions. Information regarding the conditions under which the full amount of usable fuel in each tank can safely be used must be made available to the operating personnel by a suitable placard or by instructions in the airplane flight manual.

(b) For test purposes, the amount of fuel to be used to show compliance with this section must be chosen by the applicant. In addition, when establishing the unusable fuel supply, the following conditions must be arranged in order, from the most to the least critical:

(1) Level flight at maximum continuous power, or at the power required for level flight at V_C, whichever is lower.

(2) Climb at maximum continuous power at the calculated best angle of climb at minimum weight.

(3) Rapid application of power and subsequent transition to best rate of climb following a power-off glide at 1.3 V_{S_0}.

(4) Slips and skids in level flight, climb, and glide, under the applicable conditions specified in subparagraphs (1), (2), and (3) of this paragraph, of the greatest severity likely to be encountered in normal service or turbulent air.

(c) For each acrobatic and utility category airplane, there may be no evidence of malfunctioning during all maneuvers in the airplane flight manual. During this test the amount of fuel in each tank may not exceed the unusable fuel supply established in accordance with paragraph (b) of this section, plus 0.03 gallon for each maximum continuous horsepower for which certification is requested.

(d) There may be no evidence of malfunctioning during takeoff and one minute of climb at the calculated attitude of best angle of climb at takeoff power and minimum weight where the takeoff is begun with the amount of fuel in each tank specified in paragraph (c) of this section.

(e) If an engine can be supplied with fuel from more than one tank, it must be possible, in level flight, to regain full power and fuel pressure to that engine in not more than 10 seconds (for single-engine airplanes) or 20 seconds (for multiengine airplanes) after switching to any full tank after engine malfunctioning due to fuel depletion becomes apparent while the engine is being supplied from any other tank.

[Revision note: Based on § 3.437]

§ 23.829 Fuel system hot weather operation.

Each fuel system conducive to vapor formation must be shown to be free from vapor lock when using fuel at a temperature of 110° F. under critical operating conditions.

[Revision note: Based on § 3.438]

§ 23.831 Flow between interconnected tanks.

It may not be possible in a gravity feed system with interconnected tank outlets, for enough fuel to flow between the tanks to cause an overflow of fuel from any tank vent when the airplane is operated under the conditions in § 23.827(b)(1), (2), (3), and (4), except with full tanks.

[Revision note: Based on § 3.439]

FUEL TANKS

§ 23.841 General.

Each fuel tank must be able to withstand any vibration, inertia, and fluid and structural load to which it may be subject in operation. Each flexible fuel tank liner must be of an approved type. Each integral fuel tank must have adequate facilities for interior inspection and repair. The total usable capacity of the fuel tank must be enough for at least one-half hour of operation at rated maximum continuous power. The unusable capacity is considered to be the minimum amount of fuel that allows compliance with § 23.827 Each fuel quantity indicator must be adjusted, as specified in § 23.793, to account for the unusable fuel supply. If the unusable fuel supply in any tank exceeds five percent of the tank capacity, or one gallon, whichever is greater, there must be a placard and a suitable notation in the airplane flight manual to show flight personnel that the fuel remaining in the tank when the quantity indicator reads "zero" cannot be used safely in flight. The weight of the unusable fuel supply must be included in the empty weight of the airplane.

[Revision note: Based on § 3.440]

§ 23.843 Fuel tank tests.

(a) Each fuel tank must be able to withstand the following pressure tests without failure or leakage:

(1) For each conventional metal tank and nonmetallic tank with walls not supported by the airplane structure, a pressure of 3.5 p.s.i., or that pressure developed during the maximum ultimate acceleration of the airplane with a full tank, whichever is greater.

(2) For each integral tank, the pressure developed during the maximum limit acceleration of the airplane with a full tank, with simultaneous application of the critical limit structural loads.

(3) For each nonmetallic tank with walls that are supported by the airplane structure and constructed of an acceptable basic tank material and type of construction, and with actual or simu-

lated support conditions, a pressure of 2 p.s.i. for the first tank of a specific design. The supporting structure must be designed for the critical loads occurring in the flight or landing strength conditions combined with the fuel pressure loads resulting from the corresponding accelerations.

(b) Each fuel tank with large, unsupported, or unstiffened flat areas, must be able to withstand the following tests without leakage or failure:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation. The tank assembly must be vibrated for 25 hours at a total amplitude of not less than 1/32 of an inch while 2/3 filled with water. The frequency of vibration must be 90 percent of the maximum continuous rated speed of the engine unless some other frequency within the normal operating range of speeds of the engine is more critical. If another frequency within the normal operating range of speeds is more critical, it must be used, and the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished during 25 hours at a frequency of 90 percent of the maximum continuous rated r.p.m.

(2) In conjunction with the vibration test, a sloshing test must be made in which the tank assembly is rocked through an angle of 15 degrees on either side of the horizontal (30 degrees total), about an axis parallel to the axis of the fuselage, at 16 to 20 complete cycles per minute.

(c) Each integral tank using methods of construction and sealing not previously proven to be adequate by test data or service experience must be able to withstand the vibration test specified in subparagraph (1) of paragraph (b) of this section.

(d) Each tank with a nonmetallic liner must be subjected to the sloshing test outlined in subparagraph (2) of paragraph (b) of this section, with the fuel at room temperature. In addition, a specimen liner of the same basic construction as that to be used in the airplane must, when installed in a suitable test tank, satisfactorily withstand the sloshing test with fuel at a temperature of 110° F.

[Revision note: Based on § 3.441]

§ 23.845 Fuel tank installation.

(a) Each fuel tank must be supported so that tank loads are not concentrated. There must be pads to prevent chafing between the tank and its supports. Materials used for padding must be nonabsorbent or must be treated to prevent the absorption of fuel. If a flexible tank liner is used, it must be of an approved type and must be supported so that it is not required to withstand fluid loads. Interior surfaces adjacent to the liner must be smooth and free from projections that might cause wear, unless there are provisions to protect the liner at these points or unless the construction of the liner itself provides this protection. A positive pressure must be maintained within the vapor space of each bladder cell under all conditions of operation, including the critical conditions of low airspeed and rate of descent likely to be encountered.

(b) Each tank compartment must be ventilated and drained to prevent the accumulation of flammable fluids or vapors. Each compartment adjacent to a tank that is an integral part of the airplane structure must also be ventilated and drained.

(c) No fuel tank may be on the engine side of the firewall. There must be at least one-half inch of clearance between the fuel tank and the firewall. No part of the engine nacelle skin that lies immediately behind a major air opening from the engine compartment may act as the wall of an integral tank.

(d) No fuel tank may be in the personnel compartment of a multiengine airplane. If a fuel tank is in the personnel compartment of a single engine airplane, it must—

(1) If no larger than 25 gallons total capacity, be properly drained and ventilated; and

(2) If larger than 25 gallons total capacity—

(i) (For a conventional fuel tank) be isolated from the personnel compartment by fume and fuel proof enclosures; or

(ii) (For a bladder type fuel cell) have a retaining shell that is at least equivalent to a metal fuel tank in structural integrity and in fume and fuel tightness, and that is drained to the exterior of the airplane.

[Revision note: Combines §§ 3.442 and 3.442–1]

§ 23.847 Fuel tank expansion space.

Each fuel tank must have an expansion space of at least two percent of the tank capacity, unless the tank vent discharges clear of the aircraft (in which case no expansion space is required). It may not be possible to inadvertently fill the fuel tank expansion space when the airplane is in the normal ground attitude.

[Revision note: Based on § 3.443]

§ 23.849 Fuel tank sump.

Each fuel tank must have a drainable sump with an effective capacity, in all normal ground and flight attitudes, of 0.25 percent of the tank capacity, or 1/16 gallon, whichever is greater, unless—

(a) The fuel system has a sediment bowl or chamber that is accessible for drainage and has a capacity of 1 ounce for every 20 gallons of fuel tank capacity; and

(b) Each fuel tank outlet is located so that, in the normal ground attitude, water will drain from all parts of the tank to the sediment bowl or chamber.

[Revision note: Based on § 3.444]

§ 23.851 Fuel tank filler connection.

(a) Each fuel tank filler connection must be marked as specified in § 23.1521.

(b) Spilled fuel must be prevented from entering the fuel tank compartment or any part of the airplane other than the tank itself. The filler cap must provide a fuel-tight seal for the main filler opening. However, there may be small openings in the fuel tank cap for venting purposes or for the purpose of allowing passage of a fuel gauge through the cap.

[Revision note: Based on § 3.445]

§ 23.853 Fuel tank vents and carburetor vapor vents.

(a) Each fuel tank must be vented from the top part of the expansion space. Each vent outlet must be located and constructed in a manner that minimizes the possibility of its being obstructed by ice or other foreign matter. In addition, it must be constructed in a manner that prevents siphoning of fuel during normal operation. The vent must be large enough to allow the rapid relief of excessive differences of pressure between the interior and exterior of the tank. Airspaces of tanks with interconnected outlets must also be interconnected. There may be no undrainable points in the vent line where moisture is apt to accumulate with the airplane in either the ground or level flight attitudes. No vent may terminate at a point where the discharge of fuel from the vent outlet will constitute a fire hazard or from which fumes may enter personnel compartments.

(b) Each carburetor with vapor elimination connections must have a vent line that leads vapors back to one of the airplane fuel tanks. If there is more than one fuel tank, and if it is necessary to use these tanks in a definite sequence for any reason, the vapor vent return line must lead back to the fuel tank to be used first, unless the relative capacities of the tanks are such that return to another tank is preferable.

[Revision note: Based on § 3.446]

§ 23.855 Fuel tank vents for acrobatic category airplanes.

Excessive loss of fuel during acrobatic maneuvers, including short periods of inverted flight, must be prevented. It may not be possible for fuel to siphon from the vent when normal flight has been resumed after having executed any acrobatic maneuver for which the airplane is intended.

[Revision note: Based on § 3.447–A]

§ 23.857 Fuel tank outlet.

Each fuel tank outlet must have a screen of from 8 to 16 meshes per inch. If a finger strainer is used, the length of the strainer may not be less than four times the outlet diameter. The diameter of the strainer may not be less than the diameter of the fuel tank outlet. Each finger strainer must be accessible for inspection and cleaning.

[Revision note: Based on § 3.448]

FUEL PUMPS

§ 23.867 Fuel pump and pump installation.

(a) If there are fuel pumps to maintain a supply of fuel to the engine, at least one pump for each engine must be directly driven by the engine. The fuel pump or pumps must be adequate to meet the flow requirements of the applicable parts of §§ 23.819 through 23.825.

(b) There must be enough emergency fuel pumps to supply each engine with

fuel if any engine-driven pump fails. However, if an engine fuel injection pump (that is, a pump that supplies proper flow and pressure for fuel injection when the injection is not accomplished in a carburetor) that is certificated as an integral part of the engine is used, an emergency pump is not required. Enough emergency fuel pumps must be available for immediate use if any other pump fails. If both the normal pump and emergency pump operate continuously, there must be a means to indicate to the crew a malfunction of either pump.

[Revision note: Combines §§ 3.449 and 3.449–1]

LINES, FITTINGS, AND ACCESSORIES

§ 23.877 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported in a manner that prevents excessive vibration and so that it withstands loads due to fuel pressure and accelerated flight conditions.

(b) Each fuel line that is connected to components of the airplane between which relative motion could exist must have provisions for flexibility.

(c) The provisions for flexibility in each fuel line that may be under pressure and subjected to axial loading must incorporate flexible hose assemblies, not hose-clamp connections.

(d) Each flexible hose must be of an approved type, or must be shown to be suitable for the particular application.

(e) Each flexible hose that might be adversely affected by exposure to high temperatures may not be used in locations where excessive temperatures will exist during operation or after engine shutdown.

[Revision note: Based on § 3.550]

§ 23.879 Fuel valves.

(a) There must be a means to allow the flight personnel to rapidly shut off, in flight, the flow of fuel to each engine individually. Valves for this purpose must be on the side of the firewall most remote from the engine.

(b) There must be a means to guard against inadvertent operation of each shutoff valve and to allow flight personnel to reopen each valve rapidly after it has been closed.

(c) Each valve must have either positive stops or "feel" in the "on" and "off" positions, and must be supported so that loads resulting from its operation or from accelerated flight conditions are not transmitted to the lines connected to the valve. Each valve must be installed so that the effect of gravity and vibration will tend to turn its handle to the open or "on" position, not the closed or "off" position.

(d) Each fuel valve handle and its connections to the valve mechanism must have design features that minimize the possibility of incorrect installation.

[Revision note: Based on § 3.551]

§ 23.881 Fuel strainer.

The airplane must have a fuel strainer between the fuel tank outlet and the carburetor inlet. If there is an engine-driven fuel pump, the strainer must be the tank outlet and the engine-driven pump inlet. The strainer must be accessible for drainage and cleaning, and the strainer screen must be removable.

[Revision note: Based on § 3.552]

DRAINS

§ 23.891 Fuel system drains.

The airplane must have drains to permit safe drainage of the entire fuel system. Each drain must have a means to lock it in the closed position, and must be effective in the normal ground attitude.

[Revision note: Based on § 3.553]

OIL SYSTEM

§ 23.903 Oil system.

(a) Each engine must have an independent oil system that is able to supply the engine with an ample amount of oil at a temperature not exceeding the maximum which has been established as safe for continuous operation. The usable oil tank capacity may not be less than the product of the endurance of the airplane under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to assure adequate system circulation and cooling.

(b) For a conventional oil system (that is, an oil system without an oil transfer system), only the usable oil tank capacity may be considered. The amount of oil in the engine oil lines, the oil radiator, and the feathering reserve, may not be considered. If an oil transfer system is used, and the transfer pump can pump some of the oil in the transfer lines into the main engine oil tanks, the amount of oil in these lines that can be pumped by the transfer pump may be included in the oil capacity.

[Revision note: Combines §§ 3.561 and 3.561–1(b)]

OIL TANKS

§ 23.915 Oil tanks.

Each oil tank must be able to withstand all vibration, inertia, and fluid, loads to which it might be subjected in operation. Each flexible oil tank liner must be of an acceptable type.

[Revision note: Based on § 3.563]

§ 23.917 Oil tank tests.

Each oil tank must be tested in accordance with, and meet the same test requirements as, a fuel tank except that—

(a) The applied pressure must be five p.s.i. for all tank construction instead of the pressures specified in § 23.843(a); and

(b) For a tank with a nonmetallic liner the test fluid must be oil rather than fuel as specified in § 23.843(d), and the slosh test on a specimen liner must be conducted with the oil at a temperature of 250° F.

[Revision note: Based on § 3.564]

§ 23.919 Oil tank installation.

Each oil tank installation must conform to § 23.845 (a) and (b).

[Revision note: Based on § 3.565]

§ 23.921 Oil tank expansion space.

Each oil tank must have an expansion space of at least 10 percent of the tank capacity, or ½ gallon, whichever is greater. It must not be possible to inadvertently fill the oil tank expansion space when the airplane is in the normal ground attitude.

[Revision note: Based on § 3.566]

§ 23.923 Oil tank filler connection.

Each oil tank filler connection must be marked as specified in § 23.1521.

[Revision note: Based on § 3.567]

§ 23.925 Oil tank vent.

(a) Each oil tank must be vented to the engine crankcase from the top of the expansion space so that the vent connection is not covered by oil under any normal flight conditions. Each oil tank vent must be arranged so that condensed water vapor which might freeze and obstruct the line cannot accumulate at any point.

(b) For acrobatic category airplanes, there must be provisions to prevent hazardous loss of oil during acrobatic maneuvers, including short periods of inverted flight.

[Revision note: Based on § 3.568]

§ 23.927 Oil tank outlet.

No oil tank outlet may be enclosed or covered by any screen or other guard that might impede the flow of oil. No oil tank outlet diameter may be less than the diameter of the engine oil pump inlet.

[Revision note: Based on § 3.569]

LINES, FITTINGS, AND ACCESSORIES

§ 23.937 Oil system lines, fittings, and accessories.

Each oil line must conform to § 23.877, except that the inside diameter of the engine oil inlet and outlet lines may not be less than the diameter of the corresponding engine oil pump inlet and outlet.

[Revision note: Based on § 3.570]

§ 23.941 Oil radiators.

Each oil radiator and its supporting structures must be able to withstand any vibration, inertia, and oil pressure load to which it might normally be subjected.

[Revision note: Based on § 3.572]

§ 23.943 Oil filters.

If the powerplant installation has an oil filter (strainer), the filter must be constructed and installed so that oil continues to flow at the normal rate through the remainder of the system when the flow of oil through the filter element is completely blocked.

[Revision note: Based on § 3.573]

§ 23.945 Oil system drains.

The airplane must have drains to permit safe drainage of the entire oil system. Each drain must have a means to positively lock it in the closed position.

[Revision note: Based on § 3.574]

§ 23.947 Engine breather lines.

(a) Each engine breather line must be arranged so that condensed water vapor

that might freeze and obstruct the line cannot accumulate at any point. A breather may not discharge in a location where the discharge will constitute a fire hazard if foaming occurs or where the oil emitted from the line will impinge upon the pilot's windshield. A breather may not discharge into the engine air induction system.

(b) For acrobatic category airplanes, there may be no excessive loss of oil from the breather during acrobatic maneuvers, including short periods of inverted flight.

[Revision note: Based on § 3.575]

§ 23.951 Propeller feathering system.

If the propeller feathering system depends on using engine oil supply, there must be provisions to trap an amount of oil in the tank if the supply becomes depleted due to failure of any part of the lubricating system, other than the tank itself. The amount of oil trapped must be enough to accomplish the feathering operation and must be available only to the feathering pump. The ability of the system to accomplish feathering when the supply of oil has fallen to the above level must be shown.

[Revision note: Based on § 3.577]

COOLING

§ 23.961 General.

The powerplant cooling provisions must be able to maintain the temperatures of all powerplant components and fluids within the established limits during ground and flight operation.

[Revision note: Based on § 3.581]

TESTS

§ 23.971 Cooling tests.

(a) Compliance with § 23.961 must be shown under critical ground, water, and flight operating conditions in accordance with the test procedures set forth in §§ 23.975 and 23.977.

(b) If the tests are conducted under conditions that deviate from the highest anticipated summer air temperature, the recorded powerplant temperatures must be corrected in accordance with paragraphs (c) and (d) of § 23.973. The corrected temperatures determined in this manner may not exceed the established safe values.

(c) The fuel used during the cooling tests must be the minimum grade approved for the engines involved, and the mixture settings must be the settings appropriate to the operating conditions.

(d) Water taxiing tests must be conducted on each flying boat that may reasonably be expected to be taxied for extended periods.

[Revision note: Combines §§ 3.582 (less last sentence) and 3.582–1]

§ 23.973 Temperature corrections and assumptions.

The following temperature corrections and assumptions must be used to determine compliance with the cooling test requirements:

(a) The maximum anticipated summer air temperature is considered to be 100° F. at sea level and to decrease from this value at the rate of 3.6° F. per thousand feet of altitude above sea level.

(b) Cooling test results for winterization installations may be corrected to any temperature desired by the applicant rather than the conventional 100° F. hot day.

(c) Cylinder head, oil inlet, carburetor air, and engine coolant inlet temperatures must be corrected by adding to them the difference between the maximum anticipated summer air temperature and the temperature of the ambient air at the time of the first occurrence of maximum head, air, oil, or coolant temperature recorded during the cooling test.

(d) Cylinder barrel temperatures must be corrected by adding to them 0.7 of the difference between the maximum anticipated summer air temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

[Revision note: Combines §§ 3.583, 3.583–1 (1st sentence), 3.584, and 3.585]

§ 23.975 Cooling test procedures for single-engine airplanes.

(a) Engine cooling tests for each single-engine airplane must be conducted in the following manner:

(1) Stabilize the engine temperatures in flight with the engine operating at not less than 75 percent of the maximum continuous power rating.

(2) After engine temperatures have stabilized, start a climb at the lowest practicable altitude and continue the climb for one minute with the engine operating at the takeoff rating.

(3) At the end of one minute, continue the climb at maximum continuous power for at least five minutes after the occurrence of the highest temperature recorded.

(b) The climb required in paragraph (a) of this section must be conducted at a speed not more than the best rate-of-climb speed with maximum continuous power unless—

(1) The slope of the flight path at the speed chosen for the cooling test is equal to or greater than the minimum required angle of climb; and

(2) The airplane has a cylinder head temperature indicator as specified in § 23.1183.

(c) The stabilizing and climb parts of the test must be conducted with cowl flap settings selected by the applicant.

[Revision note: Based on § 3.586]

§ 23.977 Cooling test procedures for multiengine airplanes.

(a) Engine cooling tests for each multiengine airplane that meets the minimum one-engine-inoperative climb performance specified in § 23.73(c) or § 23.75(b) must be conducted in the following manner:

(1) The airplane must be in the configuration specified in § 23.73(c) or § 23.75(b), except that, when above the critical altitude, the operating engines must be operated at maximum continuous power or at full throttle.

(2) The stabilizing and climb parts of the test must be conducted with cowl flap settings selected by the applicant.

(3) The temperatures of the operating engines must be stabilized in flight, with the engines operating at not less than 75 percent of the maximum continuous power rating.

(4) After engine temperatures have stabilized, a climb must be started 1,000 feet below the engine critical altitude (or, if this is impracticable, at the lowest altitude which the terrain will allow) or 1,000 feet below the altitude at which the single-engine-inoperative rate of climb is 0.02 $V_{S_0}^2$, whichever is lower, and continue the climb for at least five minutes after the highest temperature has been recorded.

(5) The climb must be conducted at a speed not greater than the highest speed at which compliance with the climb requirement of § 23.73(c) or § 23.75(b) can be shown. If the speed used exceeds the speed for best rate of climb with one engine inoperative, the airplane must have a cylinder head temperature indicator as specified in § 23.1183.

(b) Engine cooling tests for each multiengine airplane which cannot meet the minimum one-engine-inoperative climb performance specified in § 23.73 (c) or § 23.75(b) must be conducted in the manner prescribed in paragraph (a) of this section, except that, after stabilizing temperatures in flight, the climb (or descent, for airplanes with zero or negative one-engine-inoperative rate of climb) must be commenced at as near sea level as is practicable and must be conducted at the best rate-of-climb speed (or the speed of minimum rate of descent, for airplanes with zero or negative one-engine-inoperative rate of climb).

[Revision note: Based on § 3.587]

LIQUID COOLING SYSTEMS

§ 23.985 Independent systems.

Each liquid-cooled engine must have an independent cooling system. The cooling system must be arranged so that no air or vapor can be trapped in any part of the system, except the expansion tank, during filling or during operation.

[Revision note: Based on § 3.588]

§ 23.987 Coolant tank.

The airplane must have a coolant tank. The tank capacity may not be less than one gallon, plus 10 percent of the cooling system capacity. Each coolant tank must be able to withstand all vibration, inertia, and fluid loads to which it may be subjected in operation. Each coolant tank must have an expansion space of at least 10 percent of the total cooling system capacity. It may not be possible to inadvertently fill the expansion space with the airplane in the normal ground attitude.

[Revision note: Based on § 3.589]

§ 23.989 Coolant tank tests.

Each coolant tank must be tested in accordance with the tests for, and meet the same requirements as, a fuel tank except that—

(a) The test required by § 23.843(a)(1) must be replaced with a similar test using the sum of the pressure developed during the maximum ultimate accelera-

tion with a full tank or a pressure of 3.5 pounds per square inch, whichever is greater, plus the maximum working pressure of the system; and

(b) For a tank with a nonmetallic liner, the test fluid must be coolant rather than fuel as specified in § 23.843 (d), and the slosh test on a specimen liner must be conducted with the coolant at operating temperature.

[Revision note: Based on § 3.590]

§ 23.991 Coolant tank installation.

Each coolant tank must be supported so that tank loads are distributed over a large part of the tank surface. There must be pads between the tank and its supports to prevent chafing. Material used for padding must be nonabsorbent or must be treated to prevent the absorption of flammable fluids.

[Revision note: Based on § 3.591]

§ 23.993 Coolant tank filler connection.

(a) Each coolant tank filler connection must be marked as specified in § 23.1521.

(b) Spilled coolant must be prevented from entering the coolant tank compartment or any part of the airplane other than the tank itself. Each recessed coolant filler connection must have a drain or drains that discharge clear of all parts of the airplane.

[Revision note: Based on § 3.592]

§ 23.995 Coolant system lines and fittings.

Each coolant system line and fitting must conform to § 23.877, except that the inside diameter of the engine coolant inlet and outlet lines may not be less than the diameter of the corresponding engine inlet and outlet connections.

[Revision note: Based on § 3.593]

§ 23.997 Coolant radiators.

Each coolant radiator must be able to withstand any vibration, inertia, and coolant pressure load to which it may normally be subjected. Each radiator must be supported in a manner that allows expansion due to operating temperatures and prevents the transmittal of harmful vibration to the radiator. If flammable coolant is used, the air intake duct to the coolant radiator must be located so that (in case of fire) flames issuing from the nacelle cannot strike the radiator.

[Revision note: Based on § 3.594]

§ 23.999 Cooling system drains.

Each airplane must have at least one drain to permit drainage of the entire cooling system (including the coolant tank, radiator, and the engine) when the airplane is in the normal ground attitude. Each drain must discharge clear of all parts of the airplane and must have means to positively lock it in the closed position. Each cooling system drain must be accessible.

[Revision note: Based on § 3.595]

INDUCTION SYSTEM

§ 23.1011 General.

(a) Each engine air induction system must supply an adequate amount of air to the engine under all operating conditions.

(b) Each engine must have at least two separate air intake sources, except that an engine equipped with a fuel injector must have only one air intake source if the air intake, opening, or passage, is not obstructed by a screen, filter, or other part on which ice might form and restrict the airflow so as to adversely affect engine operation. Primary air intakes may open within the cowling if that part of the cowling is isolated from the engine accessory section by a fireresistant diaphragm or if provision is made to prevent the emergence of backfire flames. Each alternate air intake must be located in a sheltered position and may not open within the cowling unless it is located so that the emergence of backfire flames will not result in a hazard. The supplying of air to the engine through the alternate air intake system of the carburetor air preheater may not result in a loss of excessive power in addition to the power lost due to the rise in the temperature of the air.

[Revision note: Based on § 3.605]

§ 23.1013 Induction system deicing and anti-icing provisions.

Each engine air induction system must have a means to prevent and eliminate ice accumulations, and must conform to the requirements of this section when the airplane is operating in air that is at a temperature of 30° F. and free of visible moisture.

(a) Each airplane with a sea level engine using a conventional venturi carburetor must have a preheater capable of providing a heat rise of 90° F. when the engine is operating at 75 percent of its maximum continuous power.

(b) Each airplane with an altitude engine using a conventional venturi carburetor must have a preheater capable of providing a heat rise of 120° F. when the engine is operating at 75 percent of its maximum continuous power.

(c) Each airplane with an altitude engine using a carburetor which has features tending to reduce the possibility of ice formation must have a preheater capable of providing a heat rise of 100° F. when the engine is operating at 60 percent of its maximum continuous power. However, the preheater need not provide a heat rise in excess of 40° F. if a fluid deicing system conforming to the requirements of §§ 23.1015 through 23.1019 is also installed.

(d) Each single-engine airplane with a sea level engine using a carburetor which has features tending to reduce the possibility of ice formation must have a sheltered alternate source of air. The preheat supplied to this alternate air intake may not be less than that provided by the engine cooling air downstream of the cylinders.

(e) Each multiengine airplane with a sea level engine using a carburetor which has features tending to reduce the possibility of ice formation must have a preheater capable of providing a heat rise of 90° F. when the engine is operating at 75 percent of its maximum continuous power.

[Revision note: Based on § 3.606]

§ 23.1015 Carburetor deicing fluid flow rate.

If a carburetor deicing fluid system is used, it must be able to supply each engine with a rate of fluid flow, expressed in pounds per hour, of not less than 2.5 multiplied by the square root of the maximum continuous power of the engine. This flow must be available to all engines simultaneously. The fluid must be introduced into the air induction system at a point close to, and upstream of, the carburetor. The fluid must be introduced in a manner that will assure that it is equally distributed over the entire cross section of the induction system air passages.

[Revision note: Based on § 3.607]

§ 23.1017 Carburetor deicing fluid system capacity.

Each carburetor deicing fluid system capacity may not be less than that required to provide fluid at the rate specified in § 23.1015 for a time equal to three percent of the maximum endurance of the airplane. However, the capacity need not exceed that required for two hours of operation, nor may it be less than that required for 20 minutes of operation, at the above flow rate. If the available preheat exceeds 50° F. but is less than 100° F., the capacity of the system may be decreased in proportion to the heat rise available in excess of 50° F.

[Revision note: Based on § 3.608]

§ 23.1019 Carburetor deicing fluid system detail design.

Each carburetor deicing fluid system must conform to the provisions for the design of a fuel system, except as specified in §§ 23.1015 and 23.1017 and except if the provisions are clearly inapplicable.

[Revision note: Based on § 3.609]

§ 23.1021 Carburetor air preheater design.

There must be means to assure adequate ventilation of the carburetor air preheater when the engine is operated in cold air. Each preheater must be constructed so that the exhaust manifold parts that it surrounds and critical parts of the preheater itself may be inspected.

[Revision note: Based on § 3.610]

§ 23.1023 Induction system ducts.

Each induction system duct must have a drain or drains that prevents the accumulation of fuel or moisture while in all normal ground and flight attitudes. No open drain may be on the pressure side of turbosupercharger installations. No drain may discharge in a location that will constitute a fire hazard. Each duct that is connected to a component of the airplane between which relative motion may exist must have provision for flexibility.

§ 23.1025 Induction system screens.

[Revision note: Based on § 3.611]

If an induction system screen is used, it must be upstream of the carburetor. It may not be possible for fuel to strike the screen. No screen may be in any part of the induction system that is the only passage through which air can

reach the engine, unless the available preheat is 100° F. or over and the screen can be deiced by the application of the heated air. No induction system screen may be deiced by means of alcohol instead of heated air.

[Revision note: Based on § 3.612]

EXHAUST SYSTEM

§ 23.1035 General.

(a) Each exhaust system must assure the safe disposal of exhaust gases without creating a fire hazard and without allowing carbon monoxide contamination of the air in personnel compartments.

(b) Unless suitable precautions are taken, no exhaust system part may be in close proximity to parts of any system carrying flammable fluids or vapors, or under parts of such a system that may be subject to leakage. Each exhaust system component must be separated by means of fireproof shields from adjacent flammable parts of the airplane which are outside the engine compartment. No exhaust gases may be discharged where they will cause a glare that seriously affects pilot visibility at night, nor may they be discharged within dangerous proximity of any fuel or oil system drains. Each exhaust system component must be ventilated to prevent points of excessively high temperature.

[Revision note: Based on § 3.615]

§ 23.1037 Exhaust manifolds.

Each exhaust manifold must be made of fireproof, corrosion-resistant materials, and must have provisions to prevent failure due to expansion when heated to operating temperatures. Each exhaust manifold must be supported so that it will withstand all vibration and inertia loads to which it may be subjected in operation. Parts of the manifold that are connected to components between which relative motion might exist must have provisions for flexibility.

[Revision note: Based on § 3.616]

§ 23.1039 Exhaust heat exchangers.

(a) Each exhaust heat exchanger must be constructed and installed in a manner that assures its ability to withstand all vibration, inertia, and other loads to which it may normally be subjected. The heat exchanger must be constructed of materials that are suitable for continued operation at high temperatures and that are adequately resistant to corrosion due to products contained in exhaust gases.

(b) There must be provisions to allow inspection of all critical parts of exhaust heat exchangers, particularly if welded construction is used. Each heat exchanger must be ventilated where it is subject to contact with exhaust gases.

[Revision note: Based on § 3.617]

§ 23.1041 Exhaust heat exchangers used in ventilating air heating systems.

Each heat exchanger used in ventilating air heating systems must be constructed so that exhaust gases may not enter the ventilating air.

[Revision note: Based on § 3.618]

FIREWALL AND COWLING

§ 23.1051 Firewalls.

Each engine, auxiliary power unit, fuel burning heater, and each other unit of combustion equipment that is to be operated in flight, must be isolated from the remainder of the airplane by firewalls, shrouds, or equivalent means.

[Revision note: Based on § 3.623]

§ 23.1055 Firewall construction.

(a) Each firewall or shroud must be constructed so that no hazardous amount of liquid, gas, or flame can pass from the engine compartment to other parts of the airplane. Each opening in the firewall or shroud must be sealed tight with fireproof grommets, bushings, or firewall fittings. Seals made of fire-resistant materials may be used on single-engine airplanes and multiengine airplanes that are not required to conform to the provisions of § 23.73(c) or § 23.75 (b) or (c) if—

(1) The airplane has an engine (or engines) with a volumetric displacement of 1,000 cubic inches or less; and

(2) Each opening in the firewall or shroud will not allow the passage of a hazardous amount of flame without seals.

(b) Each firewall or shroud must be constructed of fireproof material and must be protected against corrosion. The following test procedures for demonstrating compliance with the criteria for fireproof material must be used:

(1) The flame to which the materials are subjected must be 2,000±50° F.

(2) Sheet materials approximately 10 inches square must be subjected to the flame from a suitable burner.

(3) The flame must be large enough to maintain the required test temperature over an area approximately five inches square.

(c) Firewall materials and fittings must resist flame penetration for 15 minutes.

(d) The following materials are satisfactory for use in firewalls or shrouds without being tested as required by this section:

(1) Stainless steel sheet, 0.015 inch thick.

(2) Mild steel sheet (coated with aluminum or otherwise protected against corrosion) 0.018 inch thick.

(3) Terne plate, 0.018 inch thick.

(4) Monel metal, 0.018 inch thick.

(5) Steel or copper base alloy firewall fittings.

[Revision note: Combines §§ 3.623–1 and 3.624]

§ 23.1057 Cowling.

(a) Each cowling must be made and suported so that it can resist all vibration, inerta, and air loads to which it may normally be subjected. There must must be provisions for rapid and complete drainage of all parts of the cowling in all normal ground and flight attitudes. No drain may discharge where the discharge will cause a fire hazard.

(b) Cowling must be constructed of fire-resistant material. Each part of the airplane behind an opening in the engine compartment cowling must be made of fire-resistant material for a distance of at least 24 inches aft of the opening. Each part of the cowling that is subjected to high temperatures due to proximity to exhaust system ports or exhaust gas impingement, must be made of fireproof material.

[Revision note: Based on § 3.625]

POWERPLANT CONTROLS AND ACCESSORIES

CONTROLS

§ 23.1067 Powerplant controls.

Each powerplant control must conform to §§ 23.697 and 23.1503. Each control must maintain any necessary position without constant attention by the flight personnel and may not have a tendency to creep due to control loads or vibration. Each flexible control must be of an acceptable type. Each control must have adequate strength and rigidity to withstand operating loads without failure or excessive deflection.

[Revision note: Based on § 3.627]

§ 23.1069 Throttle controls.

The airplane must have a throttle control to give independent control for each engine. Each throttle control must give a positive and immediately responsive means of controlling the engine. Throttle controls must be grouped and arranged so that separate control of each engine and simultaneous control of all engines is possible.

[Revision note: Based on § 3.628]

§ 23.1071 Ignition switches.

Each ignition switch must provide control for each ignition circuit on each engine. It must be possible to quickly shut off all ignition on multiengine airplanes, either by grouping of the individual switches or by providing a master ignition control. If the system has a master control, there must be means to prevent its inadvertent operation.

[Revision note: Based on § 3.629]

§ 23.1073 Mixture controls.

If the airplane has mixture controls, each engine must have a separate control. The mixture controls must be grouped and arranged so that separate control of each engine and simultaneous control of all engines is possible.

[Revision note: Based on § 3.630]

§ 23.1075 Propeller speed and pitch controls.

If the airplane has propeller speed or pitch controls, the controls must be grouped and arranged so that separate control of each engine and simultaneous control of all propellers is possible. The controls must permit ready synchronization of all propellers on multiengine airplanes.

[Revision note: Based on § 3.631]

§ 23.1077 Propeller feathering controls.

If the airplane has propeller feathering controls, each propeller must have a separate control. Propeller feathering controls must have means to prevent inadvertent operation.

[Revision note: Based on § 3.632]

§ 23.1079 Fuel system controls.

Each fuel system control must conform to § 23.879(c).

[Revision note: Based on § 3.633]

§ 23.1081 Carburetor air preheat controls.

The airplane must have separate controls to regulate the temperature of the carburetor air for each engine.

[Revision note: Based on § 3.634]

ACCESSORIES

§ 23.1091 Powerplant accessories.

Each engine-driven accessory must be of a type satisfactory for installation on the engine involved, and must use the provisions made on the engine to mount the unit. Electrical equipment subject to arcing or sparking must be installed in a manner that minimizes the possibility of contact with any flammable fluids or vapors that might be present in a free state.

[Revision note: Based on § 3.635]

§ 23.1093 Engine battery ignition systems.

(a) Each battery ignition system must be supplemented with a generator that is automatically made available as an alternate source of electrical energy, allowing continued engine operation in the event of the depletion of any battery.

(b) The capacity of batteries and generators must be enough to meet the simultaneous demands of the engine ignition system and the greatest demands of other electrical system components that draw electrical energy from the same source. The condition of an inoperative generator, and the condition of a completely depleted battery when the generator is running at its normal operating speed, must be considered. If there is only one battery, the condition in which the battery is completely depleted and the generator is operating at idling speed must be considered.

(c) The airplane must have a means to warn the appropriate flight personnel if malfunctioning of any part of the electrical system is causing the continuous discharging of a battery used for engine ignition.

[Revision note: Based on § 3.636]

POWERPLANT FIRE PROTECTION

§ 23.1103 Flammable fluids; shutoff means for multiengine aircraft which must conform to the provisions of § 23.73(c) or § 23.75(b).

(a) Each engine must have a means to shut off or otherwise prevent hazardous quantities of fuel, oil, deicing fluid, and other flammable fluids from flowing into, within, or through the engine compartment, except in lines forming an integral part of an engine. The closing of the fuel shutoff valve for any engine may not make any of the fuel supply unavailable to the remaining engines.

(b) Operation of the shutoff means may not interfere with the subsequent emergency operation of other equipment such as propeller feathering devices.

(c) Each shutoff must be outside of the engine compartment unless an equally high degree of safety is provided with the shutoff inside the engine compartment. It must be shown that no hazardous amount of flammable fluid could drain into the engine compartment after shutoff has been accomplished.

(d) The airplane must have a means to guard against inadvertent operation of the shutoff, and to make it possible for the crew to reopen the shutoff in flight after it has been closed.

[Revision note: Based on § 3.637]

§ 23.1105 Lines and fittings.

(a) Each line or fitting carrying a flammable fluid in the engine compartment must be fire resistant except—

(1) A line or fitting that forms an integral part of the engine; and

(2) A vent, drain line, or its fittings, the failure of which will not result in, or add to, a fire hazard.

(b) If flexible hose is used, the assembly of hose and end fittings must be of an approved type.

[Revision note: Based on § 3.638]

Subpart F—Equipment

§ 23.1125 General.

(a) The equipment specified in § 23.1129 must be used to show compliance with this part.

(b) Unless otherwise provided, additional equipment specified in other parts of this chapter for special types of operation is not required in order to show compliance with this part.

[Revision note: Based on § 3.651]

§ 23.1127 Functional and installation requirements.

(a) Each item of equipment that is essential to the safe operation of the airplane, including radio communication and navigation equipment installed on the airplane, must be found by the Administrator to adequately perform the functions for which it is to be used, must function properly when installed, and, where appropriate, must be adequately labeled as to its identification, function, and operating limitations.

(b) The installation of radio equipment must conform to § 23.1359.

[Revision note: Combines §§ 3.652 and 3.652-1]

BASIC EQUIPMENT

§ 23.1129 Required basic equipment.

The required basic equipment items are as follows:

(a) Flight and navigational instruments:

(1) Airspeed indicator.

(2) Altimeter.

(3) Magnetic direction indicator.

(b) Powerplant instruments for each engine or tank (if required):

(1) Fuel quantity indicator.

(2) Oil pressure indicator.

(3) Oil temperature indicator.

(4) Tachometer.

(5) Cylinder head temperature indicator.

(6) Fuel pressure indicator (if pump-fed engines are used).

(7) Manifold pressure indicator (if altitude engines are used).

(8) Oil quantity indicator.

(c) Electrical equipment (if required)

(1) Master switch arrangement.

(2) Adequate source(s) of electrical energy.

(3) Electrical protective devices.

(d) Miscellaneous equipment:

(1) Approved safety belts for all occupants.

(2) Airplane flight manual (if required by § 23.1541).

[Revision note: Based on § 3.655]

INSTRUMENTS; INSTALLATION

GENERAL

§ 23.1139 Arrangement and visibility of instrument installations.

(a) Each flight, navigation, and powerplant instrument must be easily visible to each pilot for whom its use is intended.

(b) For each multiengine airplane, identical powerplant instruments for the engines must be located in a manner that prevents confusion as to which engine the instruments relate.

[Revision note: Based on § 3.661]

§ 23.1141 Instrument panel vibration characteristics.

Vibration characteristics of the instrument panel may not impair the accuracy of any instrument or cause damage to it.

[Revision note: Based on § 3.662]

FLIGHT AND NAVIGATIONAL INSTRUMENTS

§ 23.1151 Airspeed indicating system.

(a) Except for an allowable installational error of plus or minus three percent of the calibrated airspeed, or five miles per hour, whichever is greater, each airspeed indicating system must indicate true airspeed at sea level under standard conditions—

(1) At all speeds from V_0 to 1.3 V_{S_1}, with flaps up; and

(2) At 1.3 V_{S_1}, with flaps extended.

(b) Calibration of each airspeed indicating system must be made in flight.

[Revision note: Based on § 3.663]

§ 23.1153 Airspeed indicator marking.

Each airspeed indicator must be marked in accordance with the requirements of § 23.1485.

[Revision note: Based on § 3.664]

§ 23.1155 Static air vent system.

Each instrument with static air case connections must be vented so that the influence of airplane speed, the opening and closing of windows, airflow variation, and moisture or other foreign matter does not seriously affect its accuracy.

[Revision note: Based on § 3.665]

§ 23.1157 Magnetic direction indicator.

Each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the airplane's vibration or magnetic fields. In addition, the magnetic direction indicator must be installed so that, after it has been compensated, the deviation in level flight does not exceed ten degrees on any heading.

[Revision note: Based on § 3.666]

§ 23.1159 Automatic pilot system.

If an automatic pilot system is installed, the following requirements apply:

(a) The system must be designed so that the automatic pilot can either be quickly and positively disengaged by the human pilot to prevent it from interfering with the control of the airplane, or be overpowered by the human pilot to enable him to control the airplane.

(b) Unless there is automatic synchronization, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.

(c) Each manually operated control for the system's operation must be readily accessible to the pilot. Each control must operate in the same plane and sense of motion as specified in § 23.697 for cockpit controls. The direction of motion must be plainly indicated on, or adjacent to, each control.

(d) Each automatic pilot system must be designed and adjusted so that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path under any conditions of flight appropriate to its use, either during normal operation or in the event of a malfunction, assuming that corrective action is initiated within a reasonable period of time.

(e) Each system must be designed so that a single malfunction will not produce a hardover signal in more than one control axis. If the automatic pilot integrates signals from auxiliary controls or furnishes signals for operation of other equipment, positive interlocks and sequencing of engagement to preclude improper operation are required. Protection against adverse interaction of integrated components, resulting from a malfunction, is also required.

[Revision note: Based on § 3.667]

§ 23.1161 Gyroscopic instruments.

Each gyroscopic instrument installed in airplanes must derive its energy from power sources of sufficient capacity to maintain its required accuracy at all airplane speeds above the best rate-of-climb speed. It must be installed in a manner that prevents malfunctioning due to rain, oil, and other detrimental elements. There must be a means to indicate the adequacy of the power being supplied to the instruments. In addition, the following applies to multiengine airplanes:

(a) There must be at least two independent sources of power (not driven by the same engine), a manual or an automatic means for selecting the power source, and a means for indicating the adequacy of the power being supplied by each source.

(b) The installation and power supply systems must be designed so that—

(1) The failure of one instrument will not interfere with the proper supply of energy to the remaining instruments; and

(2) The failure of the energy supply from one source will not interfere with the proper supply of energy from any other source.

[Revision note: Based on § 3.668]

§ 23.1163 Flight director instrument.

If the airplane has a flight director instrument, the installation may not affect the performance and accuracy of the required instruments. There must be a means for disconnecting the flight director instrument from the required instruments or their installations.

[Revision note: Based on § 3.669]

POWERPLANT INSTRUMENTS

§ 23.1173 Operational markings.

Instruments must be marked as specified in § 23.1489.

[Revision note: Based on § 3.670]

§ 23.1175 Instrument lines.

Each powerplant instrument line must conform to § 23.877. In addition, an instrument line carrying inflammable fluids or gasses under pressure must have restricted orifices or other safety devices at the source of the pressure to prevent escape of excessive fluid or gas if the line fails.

[Revision note: Based on § 3.671]

§ 23.1177 Fuel quantity indicator.

(a) Each airplane must have a means to indicate to the flight personnel the quantity of fuel in each tank during flight. Tanks with interconnected outlets and airspaces may be considered as one tank and need not have separate indicators. Each exposed sight guage must be installed and guarded in a manner that precludes the possibility of breakage or damage. A sight gauge that forms a trap in which water can collect and freeze must have means to permit drainage on the ground. Each fuel quantity gauge must be calibrated to read "zero" during level flight when the amount of fuel remaining in the tank is equal to the unusable fuel supply determined under § 23.827.

(b) No fuel gauge is required for a small auxiliary tank that is used only to transfer fuel to other tanks if the relative size of the tank, the rate of fuel transfer, and operating instructions are adequate to—

(1) Guard against overflow; and

(2) Give the crew prompt warning if transfer is not proceeding as planned.

(c) A fuel tank gauge calibrated to read in either gallons or pounds, and clearly marked to indicate which scale is being used, may be used.

[Revision note: Combines §§ 3.672 and 3.672–1]

§ 23.1179 Fuel flowmeter system.

If there is a fuel flowmeter system in the fuel line, the metering component must have a suitable means for the purpose of bypassing the fuel supply in the event that a malfunction of the metering component severely restricts fuel flow.

[Revision note: Based on § 3.673]

§ 23.1181 Oil quantity indicator.

The airplane must have a ground means (such as a stick gauge) to indicate the quantity of oil in each tank. If there is an oil transfer system or a reserve oil supply system, there must be means to indicate the quantity of oil in each tank to the flight personnel, during flight.

[Revision note: Based on § 3.674]

§ 23.1183 Cylinder head temperature indicating system for air-cooled engines.

Each air-cooled engine on airplanes equipped with cowl flaps must have a cylinder head temperature indicator. An airplane that does not have cowl flaps must have an indicator if compliance with § 23.961 is shown at a speed in excess of the speed of best rate of climb.

[Revision note: Based on § 3.675]

ELECTRICAL SYSTEMS AND EQUIPMENT

§ 23.1193 Installation.

Each electrical system must be of a type and design that is adequate for the intended use. In addition, when installed, it must be—

(a) Free from hazards in itself, in its method of operation, and in its effects on other parts of the airplane; and

(b) Suitably protected from fuel, oil, water, other detrimental substances, and mechanical damage.

[Revision note: Based on § 3.681]

ELECTRIC POWER SOURCES

§ 23.1203 Electric power sources.

(a) Each electric power source, its transmission cables, and its associated control and protective devices, must have enough capacity to furnish the required power at the proper voltage to all load circuits essential to the safe operation of the airplane.

(b) Compliance with paragraph (a) of this section must be shown by means of an electrical load analysis, or by electrical measurements, that take into account all electrical loads applied to the electrical system in probable combinations and for probable durations.

(c) There must be at least one generator if the electrical system supplies power to load circuits that are essential to the safe operation of the airplane.

(d) Electric power sources must function properly independently and when connected in combination. The failure or malfunction of any electric power source may not impair the ability of any remaining source to supply load circuits which are essential to the safe operation of the airplane.

(e) Each electric power source control must permit independent operation of each source.

[Revision note: Based on § 3.682]

§ 23.1205 Storage battery design and installation.

Unless operating experience with similar battery designs and installations shows that no temperature or pressure problems will arise with a particular battery design and installation, it must

be shown for each battery design and installation that the following conditions are met:

(a) Safe cell temperatures and pressures will be maintained during all probable charging or discharging conditions.

(b) No uncontrolled increase in cell temperature will result when the storage battery is recharged (after previous complete discharge) at the maximum regulated voltage, during a flight of maximum duration, under the most adverse cooling conditions likely to occur in service.

(c) Explosive or toxic gases emitted by the storage battery in normal operation, or as a result of any probable malfunction in the charging system or battery installation, will not accumulate in hazardous quantities within the airplane.

(d) Corrosive fluids or gases which may be emitted or spilled from the storage battery will not damage surrounding airplane structures or adjacent essential equipment.

[Revision note: Based on § 3.683]

§ 23.1207 Generator.

Each generator must be able to deliver its continuous rated power.

[Revision note: Based on § 3.685]

§ 23.1209 Generator controls.

(a) Generator voltage control equipment must be able to dependably regulate the generator output within rated limits.

(b) Each generator reverse current cutout must be designed and installed so that the generator is disconnected from the battery and other generators when the generator is developing a voltage of such a value that enough current to cause malfunctioning can flow into the generator.

[Revision note: Based on § 3.686]

INSTRUMENTS

§ 23.1219 Electric power system instruments.

(a) The airplane must have a means to indicate to appropriate crewmembers those electric power system quantities that are essential for the safe operation of the system.

(b) For direct current systems, an ammeter which can be switched into each generator feeder may be used. If there is only one generator, the ammeter may be in the battery feeder.

[Revision note: Based on § 3.687 and the note following]

MASTER SWITCH

§ 23.1221 Arrangement.

The airplane must have a master switch arrangement to allow expeditious disconnection of all electric power sources from the main bus. The point of disconnection must be adjacent to the power sources. Load circuits may be connected so that they remain energized after the master switch is opened if they are protected by circuit protective devices, rated at five amperes or less located next to the electric power source.

[Revision note: Based on § 3.688]

§ 23.1223 Master switch installation.

Each master switch or its controls must be installed so that it is easily discernible and accessible to a member of the crew in flight.

[Revision note: Based on § 3.689]

PROTECTIVE DEVICES

§ 23.1233 Fuses or circuit breakers.

Protective devices (fuses or circuit breakers) must be installed in the circuits of all electrical equipment except the main circuits of starter motors or other circuits where no hazard is presented by their omission. Not more than one circuit that is essential to safety in flight may be protected by a single protective device. Each resettable type circuit protective device must be designed so that a manual operation is required to restore service after tripping, and so that, when an overload or circuit fault exists, it will open the circuit irrespective of the position of the operating control.

[Revision note: Based on § 3.690]

§ 23.1235 Protective devices installation.

If the ability to reset a circuit breaker or to replace a fuse is essential to safety in flight, the circuit breaker or fuse must be in a position and identified so that it can be readily reset or replaced in flight.

[Revision note: Based on § 3.691]

§ 23.1237 Spare fuses.

If fuses are used, there must be one spare of each rating, or 50 percent spare fuses of each rating, whichever is greater.

[Revision note: Based on § 3.692]

ELECTRIC CABLES

§ 23.1247 Electric cables.

Each electric connecting cable must be of adequate capacity. A cable that would overheat in the event of circuit overload or fault must be flame resistant and may not emit dangerous quantities of toxic fumes.

[Revision note: Based on § 3.693]

SWITCHES

§ 23.1249 Switches.

Each switch must be able to carry its rated current and must be constructed with sufficient distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting.

[Revision note: Based on § 3.694]

§ 23.1251 Switch installation.

Each switch must be installed so that it is readily accessible to the appropriate crewmember. Each switch must be suitably labeled as to operation and the circuit controlled.

[Revision note: Based on § 3.695]

INSTRUMENT LIGHTS

§ 23.1261 Instrument lights.

If there are instrument lights, they must be constructed with sufficient distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting. They must provide sufficient illumination to make all instruments and controls easily readable and discernible. A cabin dome light is not an instrument light.

[Revision note: Combines §§ 3.696 and 3.696–1]

§ 23.1263 Instrument light installation.

Instrument lights must be installed so that their direct rays, and rays reflected from the windshield or other surface, are shielded from the pilot's eyes.

[Revision note: Based on § 3.697]

LANDING LIGHTS

§ 23.1273 Landing lights.

If there are landing lights, they must be of acceptable types.

[Revision note: Based on § 3.698]

§ 23.1275 Landing light installation.

Landing lights must be installed so that no dangerous glare is visible to the pilot and so that the pilot is not seriously affected by halation. In addition, they must provide adequate illumination for night landing.

[Revision note: Based on § 3.699]

POSITION LIGHTS

§ 23.1285 Position light system installation.

(a) Each position light system must consist of the following lights:

(1) Forward position lights consisting of a red and a green light, spaced laterally as far apart as practicable, and installed in a forward location on the airplane so that, with the airplane in normal flying position, the red light is displayed on the left side and the green light is displayed on the right side. The individual lights must be of approved types.

(2) A rear position white light, mounted as far aft as practicable. The light must be of an approved type.

(b) The two forward position lights and the rear position light must make a single circuit.

(c) The light covers or color filters used must be made of flame-resistant material and must be constructed so that they will not change color or shape, or suffer any appreciable loss of light transmission, during normal use.

[Revision note: Based on § 3.700]

§ 23.1287 Position light system dihedral angles.

The forward and rear position lights, when installed on the airplane, must show unbroken light within the dihedral angles specified in this section.

(a) Dihedral angle *L* (left) is formed by two intersecting vertical planes, one parallel to the longitudinal axis of the airplane and the other at 110 degrees to the left of the first, when looking forward along the longitudinal axis.

(b) Dihedral angle *R* (right) is formed by two intersecting vertical planes, one parallel to the longitudinal axis of the

airplane and the other 110 degrees to the right of the first, when looking forward along the longitudinal axis.

(c) Dihedral angle *A* (aft) is formed by two intersecting vertical planes making angles of 70 degrees to the right and 70 degrees to the left, respectively, looking aft along the longitudinal axis, to a vertical plane passing through the longitudinal axis.

[Revision note: Based on § 3.701]

§ 23.1289 Position light distribution and intensities.

(a) *General.* The intensities prescribed in this section are for new equipment with all light covers and color filters in place. Intensities must be determined with the light source operating at a steady value equal to the average luminous output of the light source at the normal operating voltage of the airplane. The light distribution and intensities of position lights must conform to the provisions of this section.

(b) *Forward and rear position lights.* The light distribution and intensities of forward and rear position lights are expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane, and maximum intensities in overlapping beams within dihedral angles *L*, *R*, and *A*. They must conform to the following requirements:

(1) *Intensities in horizontal plane.* The intensities in the horizontal plane may not be less than the values in § 23.1291. (The horizontal plane is the plane containing the longitudinal axis of the airplane and is perpendicular to the plane of symmetry of the airplane.)

(2) *Intensities above and below horizontal.* The intensities in any vertical plane may not be less than the appropriate value in § 23.1293 where I is the minimum intensity prescribed in § 23.1291 for the corresponding angles in the horizontal plane. (Vertical planes are planes perpendicular to the horizontal plane).

(3) *Overlaps between adjacent signals.* The intensities in overlaps between adjacent signals may not exceed the values in § 23.1295. However, higher intensities in the overlaps may be used with main beam intensities substantially greater than the minima specified in §§ 23.1291 and 23.1293 if the overlap intensities in relation to the main beam intensities do not adversely affect signal clarity. If the peak intensity of the forward position lights is greater than 100 candles, the maximum overlap intensities between them may exceed the values in § 23.1295 if the overlap intensity in Area *A* is not more than 10 percent of peak position light intensity, and the overlap intensity in Area *B* is not more than 2.5 percent of peak position light intensity.

(c) *Rear position light installation.* A single rear position light may be installed in a position displaced laterally from the plane of symmetry of an airplane if the axis of the maximum cone of illumination is parallel to the flight path in level flight, and if there is no obstruction aft of the light and between planes 70 degrees to the right and left of the axis of maximum illumination.

[Revision note: Combines §§ 3.702, 3.702–1, and 3.702–2]

§ 23.1291 Minimum intensities in the horizontal plane of forward and rear position lights.

Dihedral angle (light involved)	Angle from right or left of longitudinal axis, measured from dead ahead	Intensity (candles)
L and *R* (forward red and green).	0° to 10°	40
	10° to 20°	30
	20° to 110°	5
A (rear white)	110° to 180°	20

[Revision note: Based on figure 3–15]

§ 23.1293 Minimum intensities in any vertical plane of forward and rear position lights.

Angle above or below horizontal	Intensity
0°	1.00 *I.*
0° to 5°	0.90 *I.*
5° to 10°	0.80 *I.*
10° to 15°	0.70 *I.*
15° to 20°	0.50 *I.*
20° to 30°	0.30 *I.*
30° to 40°	0.10 *I.*
40° to 90°	0.05 *I.*

[Revision note: Based on figure 3–16]

§ 23.1295 Maximum intensities in overlapping beams of forward and rear position lights.

Overlaps	Maximum intensity	
	Area A (candles)	Area B (candles)
Green in dihedral angle *L*	10	1
Red in dihedral angle *R*	10	1
Green in dihedral angle *A*	5	1
Red in dihedral angle *A*	5	1
Rear white in dihedral angle *L*	5	1
Rear white in dihedral angle *R*	5	1

Area A includes all directions in the adjacent dihedral angle which pass through the light source and which intersect the common boundary plane at more than 10 degrees but less than 20 degrees. Area B includes all directions in the adjacent dihedral angle which pass through the light source and which intersect the common boundary plane at more than 20 degrees.

[Revision note: Based on figure 3–17]

§ 23.1297 Color specifications.

Position light colors must conform to the following chromaticity coordinates of the International Commission on Illumination:

(a) *Aviation red.*

y is not greater than 0.335,
z is not greater than 0.002.

(b) *Aviation green.*

x is not greater than $0.440-0.320y$,
x is not greater than $y-0.170$,
y is not less than $0.390-0.170x$

(c) *Aviation white.*

x is not less than 0.350
x is not greater than 0.540,
$y-y_0$ is not numerically greater than 0.01, y_0 being the y coordinate of the Planckian radiator for which $x_0=x$.

[Revision note: Based on § 3.703]

RIDING LIGHT (SEAPLANES)

§ 23.1305 Riding light.

(a) If a riding (anchor) light is required for a seaplane, flying boat, or amphibian, it must be able to show a white light for at least two miles at night under clear atmospheric conditions.

(b) Each riding light must be installed so that it shows the maximum unbroken light practicable when the airplane is moored or drifting on the water. Externally hung lights may be used.

[Revision note: Based on § 3.704]

ANTICOLLISION LIGHT SYSTEM

§ 23.1315 Anticollision light system for air planes for which an application for a type certificate was made after March 31, 1957.

To be eligible for certification for use in night operations, airplanes for which application for type certification was made after March 31, 1957, must have an anticollision light system. The system must consist of one or more approved anticollision lights, located where the emitted light will not impair the crew's vision and will not detract from the conspicuity of the position lights. The system must conform to the following requirements:

(a) *Field of coverage.* The system must consist of a light or lights that cover all vital areas around the airplane considering the physical configuration and the flight characteristics of the airplane. The field of coverage must extend in all directions within 30 degrees above and 30 degrees below the horizontal plane of the airplane, except that a solid angle or angles of obstructed visibility totaling not more than 0.5 steradians is allowable.

(b) *Flashing characteristics.* Each system (including the number of light sources, beam width, speed of rotation, and similar characteristics) must be arranged to give an effective flash frequency of not less than 40 nor more than 100 cycles per minute. The effective flash frequency is the frequency at which the airplane's complete anticollision light system is observed from a distance, and applies to all sectors of light including the overlaps which might exist when the system consists of more than one light source. In overlaps, flash frequencies above 100 cycles per minute, but not more than 180 cycles per minute, are allowed.

(c) *Color.* The color of the anticollision lights must be aviation red, in accordance with the specifications of § 23.1297(a).

(d) *Light intensity.* The minimum light intensity in all vertical planes, measured with the red filter and expressed in "effective intensities", is as follows:

(1)

Angle above or below horizontal plane	Effective intensity (candles)
0° to 5°	100
5° to 10°	60
10° to 20°	20
20° to 30°	10

(2) The following relation is assumed:

$$I_e = \frac{\int_{t_1}^{t_2} I(t)\,dt}{0.2 + (t_2 - t_1)}$$

where—

(i) I_e = effective intensity (candlas);

(ii) $I(t)$ = instantaneous intensity as a function of time; and

(iii) $t_2 - t_1$ = flash time interval (seconds).

[Revision note: Combines §§ 3.705, figure 3-18, and 3.705-1 (1st sentence)]

§ 23.1317 Anticollision light system for airplanes for which an application for a type certificate was made before April 1, 1957.

(a) Airplanes for which application for a type certificate was made before April 1, 1957, may be certificated for night operation without an anticollision light system. If there is an anticollision light system, it must conform either to § 23.1315 or paragraphs (b) through (d) of this section.

(b) The anticollision light system must be of the rotating beacon type. It must be installed on top of the fuselage or the tail in a location where the light will not impair the flight crew's vision and will not detract from the conspicuity of the position lights. If there is no acceptable location on top of the fuselage or tail, a bottom fuselage installation may be used.

(c) The color of the anticollision light must be aviation red, in accordance with the specifications of § 23.1297(a).

(d) The arrangement of the anticollision light (the number of light sources, beam width, speed of rotation, and similar items), must provide an effective flash frequency of not less than 40 nor more than 100 cycles per minute, with an on-off ratio not less than 1: 75.

[Revision note: Based on § 3.705-1 (less 1st sentence)]

SAFETY EQUIPMENT: INSTALLATION

§ 23.1327 Marking.

Required safety equipment which the crew is expected to operate in an emergency (such as flares and automatic life raft releases) must be readily accessible and plainly marked as to method of operation. If this equipment is carried in lockers, compartments, or other storage places, the storage places must be marked for the benefit of passengers and crew.

[Revision note: Based on § 3.711]

§ 23.1329 Deicers.

If there are pneumatic deicers, the installation must be made in accordance with approved data. There must be a positive means to deflate the pneumatic boots.

[Revision note: Based on § 3.712]

§ 23.1335 Safety belts.

Each safety belt must be of an approved type. The rated strength of the safety belt may not be less than that required to withstand the ultimate load factors specified in § 23.709(b), considering the dimensional characteristics of the safety belt installation for the specific seat or berth arrangement. Each safety belt must be attached so that no part of the anchorage will fail at a load lower than that which would result from the application of ultimate load factors equal to those specified in § 23.709(b) multiplied by a factor of 1.33. This factor must be used in place of the fitting factor prescribed in § 23.505. For safety belts for berths parallel to the longitudinal axis of the airplane, the forward load factor need not be applied.

[Revision note: Based on § 3.715]

EMERGENCY FLOTATION AND SIGNALING EQUIPMENT

§ 23.1345 Rafts and life preservers.

Each raft and life preserver must be of an approved type.

[Revision note: Based on § 3.716]

§ 23.1347 Installation.

If emergency flotation and signaling equipment is required, it must be installed so that it is readily available to the crew and passengers. Each raft released automatically or by the pilot must be attached to the airplane by means of a line to keep it adjacent to the airplane. This line must be weak enough to break before submerging the empty raft.

[Revision note: Based on § 3.717]

§ 23.1349 Signaling device.

If a signaling device is required by other parts in this chapter, it must be accessible and function satisfactorily and must be free of any hazard in its operation.

[Revision note: Based on § 3.718]

RADIO EQUIPMENT: INSTALLATION

§ 23.1359 General.

Radio equipment and installations in the airplane must be free of hazards in themselves, in their method of operation, and in their effects on other components of the airplane.

[Revision note: Based on § 3.721]

MISCELLANEOUS EQUIPMENT: INSTALLATION

§ 23.1369 Accessories for multiengine airplanes.

Engine-driven accessories essential to the safe operation of the airplane must be distributed among two or more engines so that the failure of any one engine will not impair the safe operation of the airplane through the malfunctioning of these accessories.

[Revision note: Based on § 3.725]

HYDRAULIC SYSTEMS

§ 23.1379 General.

Each hydraulic system and element of the system must be designed to withstand, without exceeding the yield point, all structural loads in addition to the hydraulic loads that might be imposed.

[Revision note: Based on § 3.726]

§ 23.1381 Tests.

Each hydraulic system must be substantiated by proof pressure tests. When proof tested, no part of the hydraulic system may fail, malfunction, or experience a permanent set. The proof load of any system must be 1.5 times the maximum operating pressure of that system.

[Revision note: Based on § 3.727]

§ 23.1383 Accumulators.

No hydraulic accumulator or pressurized reservoir may be installed on the engine side of the firewall unless it is an integral part of the engine or propeller.

[Revision note: Based on § 3.728]

Subpart G—Operating Limitations and Information

§ 23.1403 General.

There must be a means to adequately inform the pilot and other appropriate crewmembers of the operating limitations upon which the type design is based. Any other information (concerning the airplane) found by the Administrator to be necessary for safety during its operation must also be made available to the crew.

[Revision note: Based on § 3.735]

LIMITATIONS

§ 23.1413 Limitations; general.

The operating limitations specified in §§ 23.1423 through 23.1463, and any similar limitations, must be established for each airplane to be certificated and made available to the operator in the manner prescribed in §§ 23.1473 through 23.1547, unless those limitations are unnecessary for safe operation because of the design of the airplane.

[Revision note: Based on § 3.737]

AIRSPEED

§ 23.1423 Airspeed limitations.

The airspeed limitations must be establish in accordance with the following:

(a) *Never-exceed speed* V_{NE}. No never-exceed speed may exceed the lesser of—

(1) 0.9 V_D chosen in accordance with § 23.245; or

(2) 0.9 times the maximum speed demonstrated in accordance with § 23.197 but not less than 0.9 times the minimum value of V_D permitted by § 23.245.

(b) *Maximum structural cruising speed* V_{NO}. No maximum structural cruising speed may be—

(1) Greater than V_C chosen in accordance with § 23.245;

(2) Greater than 0.89 times V_{NE} established under paragraph (a) of this section; and

(3) Less than the minimum V_C permitted in § 23.245.

(c) *Maneuvering speed* V_A. The maneuvering speed must be determined in accordance with § 23.245.

(d) *Flaps-extended speed* V_{FE}:

(1) No flaps-extended speed V_{FE} may be less than the minimum value of design flap speed in §§ 23.265 and 23.347, nor more than the lesser of—

(i) The design flap speed, V_F, chosen in accordance with § 23.265; or

(ii) The design flap speed chosen in accordance with § 23.247.

(2) Additional combinations of flap setting, airspeed, and engine power may be established if the structure has been proven for the corresponding design conditions.

(e) *Minimum control speed V_{MC}.* The minimum control speed must be determined in accordance with § 23.117.

[Revision note: Combines §§ 3.738 through 3.743]

POWERPLANT

§ 23.1433 Powerplant limitations.

(a) The following powerplant limitations must be established:

(1) For takeoff operation—

(i) The maximum rotational speed (r.p.m.);

(ii) The maximum allowable manifold pressure;

(iii) The maximum allowable gas temperature;

(iv) The time limit for use of the power or thrust which corresponds to the values established in subdivisions (i) through (iii) of this subparagraph; and

(v) The maximum allowable cylinder head, oil, and liquid coolant temperatures, if the time limit established in subdivision (iv) of this subparagraph exceeds two minutes.

(2) For maximum continuous operation—

(i) The maximum rotational speed (r.p.m.);

(ii) The maximum allowable manifold pressure;

(iii) The maximum allowable gas temperature; and

(iv) The maximum allowable cylinder head, oil, and liquid coolant temperatures.

(3) For takeoff and maximum continuous operation—

(i) The minimum fuel grade for reciprocating engines; or

(ii) The fuel designation for turbine engines.

(b) No powerplant limitation established under this section may exceed any corresponding limit established as part of the type certification of the engine or propeller used.

[Revision note: Based on § 3.744]

AIRPLANE WEIGHT

§ 23.1443 Airplane weight.

The airplane weight and center of gravity limitations must be determined in accordance with § 23.31.

[Revision note: Based on § 3.748]

MINIMUM FLIGHT CREW

§ 23.1453 Minimum flight crew.

The minimum flight crew must be determined as that number of persons required for the safe operation of the airplane during flight under VFR, determined by the availability and satisfactory operation of all necessary controls by each operator concerned.

[Revision note: Based on § 3.749]

KINDS OF OPERATION

§ 23.1463 Kinds of operation.

The kind of operation to which the airplane is limited is established by the category in which it is found eligible for certification and by the equipment installed.

[Revision note: Based on § 3.750]

MARKINGS AND PLACARDS

§ 23.1473 Markings and placards.

(a) Except as provided in § 23.1529 (b), all specified markings and placards are required for all airplanes certificated in the normal, utility, and acrobatic categories. Placards must be displayed in a conspicuous place. No placard or marking may be easily erased, disfigured, or obscured. Additional informational placards and instrument markings with a direct and important bearing on safe operation may be required by the Administrator because of unusual design, operating, or handling characteristics.

(b) If an airplane is to be certificated in more than one category, the applicant must select one category on which the placards and markings on the airplane are to be based. The placard and marking information for the other categories in which the airplane is to be certificated must be recorded in the airplane flight manual. A reference to this information must be on a placard which must also indicate the category on which the airplane placards and markings are based.

[Revision note: Based on § 3.755]

INSTRUMENT MARKINGS

§ 23.1483 Instrument markings.

Each instrument must be marked in accordance with §§ 23.1485 through 23.1493. If these markings are on the cover glass of the instrument, there must be adequate provisions to maintain the correct alignment of the glass cover with the face of the dial. Each arc and line must be wide enough to be clearly and easily visible to the pilot.

[Revision note: Based on § 3.756]

§ 23.1485 Airspeed indicator.

(a) Calibrated airspeed must be used. The following markings must be made:

(1) For the never-exceed speed V_{NE}, a radial red line.

(2) For the caution range, a yellow arc extending from the red line specified in subparagraph (1) to the upper limit of the green arc specified in subparagraph (3) of this paragraph.

(3) For the normal operating range, a green arc with the lower limit at V_{S_1} with maximum weight and with landing gear and wing flaps retracted, and the upper limit at the maximum structural cruising speed V_{NO} established in accordance with § 23.1423(b).

(4) For the flap operating range, a white arc with the lower limit at V_{S_0} at the maximum weight, and the upper limit at the flaps-extended speed V_{FE} established in accordance with § 23.1423 (d).

(b) If the never-exceed and maximum structural cruising speeds vary with altitude, there must be means to indicate to the pilot the appropriate limitations throughout the operating altitude range.

[Revision note: Based on § 3.757]

§ 23.1487 Magnetic direction indicator.

A placard that contains the calibration of the instrument in a level flight attitude with engine(s) operating and radio receiver(s) on or off (state which), must be installed on or in close proximity to the magnetic direction indicator. The calibrated readings must be to known magnetic headings in not greater than 30° increments.

[Revision note: Based on § 3.758]

§ 23.1489 Powerplant instruments.

Each required powerplant instrument must be marked with a red radial line at the maximum and minimum (if applicable) indications for safe operation. The normal operating ranges must be marked with a green arc that may not extend beyond the maximum and minimum limits for continuous operation. Takeoff and precautionary ranges must be marked with a yellow arc. Ranges of engine speed that are restricted because of excessive engine or propeller vibration must be marked with a red arc.

[Revision note: Based on § 3.759]

§ 23.1491 Oil quantity indicators.

Each oil quantity indicator must be suitably marked with such a number of increments that the indicator readily and accurately indicates the quantity of oil.

[Revision not: Based on § 3.760]

§ 23.1493 Fuel quantity indicator.

If the unusable fuel supply for any tank exceeds one gallon or five percent of the tank capacity, whichever is greater, there must be a red band on the fuel quantity indicator, extending from the calibrated zero reading to the lowest reading obtainable in the level flight attitude. There must be a suitable notation in the airplane flight manual to indicate to the flight personnel that the fuel remaining in the tank when the quantity indicator reads "zero" cannot be used safely in flight.

[Revision note: Based on § 3.761]

CONTROL MARKINGS

§ 23.1503 General.

Each cockpit control, except the primary flight controls and simple push button type starter switches, must be plainly marked as to its function and method of operation.

[Revision note: Combines §§ 3.762 and 3.762–1]

§ 23.1505 Aerodynamic controls.

Each secondary control must be suitably marked.

[Revision note: Based on § 3.763]

§ 23.1507 Powerplant fuel controls.

(a) Each fuel tank selector valve control must be marked to indicate the position corresponding to each tank and to all existing cross feed positions.

(b) If there is more than one fuel tank, and, if safe operation depends upon the use of tanks in a specific sequence, the fuel tank selector controls must be marked (adjacent to or on the control) to indicate to the flight personnel the order in which the tanks must be used.

(c) On each multiengine airplane, controls for engine valves must be

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marked to indicate the position corresponding to each engine.

(d) The usable capacity of each tank must be indicated adjacent to or on the fuel tank selector control.

[Revision note: Based on § 3.764]

§ 23.1509 Accessory and auxiliary controls.

(a) If retractable landing gear is used, the indicator required by § 23.631 must be marked so that the pilot can ascertain at all times that the wheels are secured in the extreme positions.

(b) Each emergency control must be colored red and clearly marked as to its method of operation.

[Revision note: Based on § 3.765]

MISCELLANEOUS

§ 23.1519 Baggage compartments, ballast location, and special seat loading limitations.

(a) Each baggage, cargo, and ballast location must bear a placard that states the maximum allowable weight for that location and, if applicable, special limitations on contents due to loading requirements.

(b) If the maximum allowable weight to be carried in a seat is less than 170 pounds, there must be a placard permanently attached to the seat structure that states the maximum allowable weight to be carried in that seat.

[Revision note: Based on § 3.766]

§ 23.1521 Fuel, oil, and coolant filler openings.

The following information must be marked on or adjacent to the filler cover:

(a) For each fuel tank, the word "fuel", the minimum allowable fuel grade or designation for the engines installed, and the usable fuel tank capacity.

(b) For each oil tank, the word "oil" and the oil tank capacity.

(c) For each coolant tank, the name of the proper coolant fluid and the capacity of the coolant system.

[Revision note: Based on § 3.767]

§ 23.1523 Emergency exit placards.

Each emergency exit placard and operating control must be colored red. There must be a placard adjacent to the control that clearly indicates the exit to be an emergency exit and describes the method of operation of the control.

[Revision note: Based on § 3.768]

§ 23.1525 Approved flight maneuvers.

(a) For normal category airplanes, there must be a placard in front of and in clear view of the pilot stating: "No acrobatic maneuvers, including spins, approved."

(b) For utility category airplanes, there must be a placard in clear view of the pilot stating: "Acrobatic maneuvers are limited to the following ——" (list approved maneuvers).

(c) For acrobatic category airplanes, there must be a placard in clear view of the pilot listing the approved acrobatic maneuvers and the recommended entry airspeed for each. If inverted flight maneuvers are not approved, the placard must bear a notation to this effect.

[Revision note: Based on § 3.769]

§ 23.1527 Operating limitations placard.

There must be a placard in clear view of the pilot stating: "This airplane must be operated as a —— or —— category airplane in compliance with the operating limitations stated in the form of placards, markings, and manuals" (insert correct categories).

[Revision note: Based on § 3.770]

§ 23.1529 Airspeed placards.

(a) *For all airplanes.* There must be an airspeed placard in clear view of the pilot and as close as practicable to the airspeed indicator. This placard must list:

(1) The maximum speed for landing gear operation and the maximum speed with landing gear extended, if the airplane is equipped with retractable landing gear;

(2) The design maneuvering speed V_A;

(3) The minimum control speed V_{MC}; and

(4) The demonstrated crosswind velocity.

(b) *For airplanes of more than 6,000 pounds.* The placard required by paragraph (a) of this section must also include—

(1) The recommended climb speed;

(2) The best angle of climb speed;

(3) The engine - inoperative - climb speed; and

(4) The demonstrated crosswind speeds.

[Revision note: Based on § 3.771]

§ 23.1531 Kinds-of-operation placard.

There must be a placard in clear view of the pilot that specifies the kind of operations (such as VFR, IFR, day, or night) and the meteorological conditions (such as icing conditions) to which the operation of the airplane is limited, or from which it is prohibited, by the equipment installed.

[Revision note: Based on § 3.772]

AIRPLANE FLIGHT MANUAL

§ 23.1541 Airplane flight manual.

(a) There must be an airplane flight manual for each airplane of more than 6,000 pounds maximum certificated weight. The parts of this document listed below must be verified and approved by the Administrator, and must be segregated, identified, and clearly distinguished from parts not so approved. Additional items of information with a direct and important bearing on safe operation may be required by the Administrator when unusual design, operating, or handling characteristics so warrant.

(b) For airplanes with a maximum certificated weight of 6,000 pounds or less, an airplane flight manual is not required. However, the information prescribed in this part for inclusion in the airplane flight manual must be made available to the operator in the form of clearly stated placards, markings, or manuals.

[Revision note: Based on § 3.777]

§ 23.1543 Operating limitations.

(a) *Airspeed limitations.* Each airplane flight manual must include enough information to allow proper marking of the airspeed limitations on the indicator, as required in § 23.1485. It must also include the design maneuvering speed and the maximum safe airspeed at which the landing gear can be safely lowered. In addition, the significance of the airspeed limitations and of the color coding used must be explained.

(b) *Powerplant limitations.* Each airplane flight manual must include enough information to outline and explain all powerplant limitations and to allow marking the instruments as required by § 23.1489.

(c) *Weight.* The airplane flight manual must include—

(1) The maximum certificated weight;

(2) The empty weight and center of gravity location;

(3) The useful load; and

(4) The composition of the useful load, including the total weight of fuel and oil with tanks full.

(d) *Load distribution.* Each airplane flight manual must include all authorized center of gravity limits. If the available space for loading the airplane is adequately placarded or arranged so that any reasonable distribution of the useful load listed in weight above will not result in a center of gravity outside of the stated limits, the manual need not include any information other than the statement of center of gravity limits. In each other case, the manual must include adequate information to indicate satisfactory loading combinations that will assure maintaining the center of gravity within approved limits.

(e) *Maneuvers.* The airplane flight manual must include the authorized maneuvers, their appropriate airspeed limitations, and the unauthorized maneuvers, in accordance with the following:

(1) *Normal category airplanes.* Acrobatic maneuvers, including spins, are unauthorized. If the airplane has been demonstrated to be "characteristically incapable of spinning" in accordance with § 23.171(d), a statement to this effect must be entered.

(2) *Utility category airplanes.* Authorized maneuvers demonstrated in the type flight tests must be listed, together with recommended entry speeds. Other maneuvers are not authorized. If the airplane has been demonstrated to be "characteristically incapable of spinning" in accordance with § 23.171(d), a statement to this effect must be entered.

(3) *Acrobatic category airplanes.* The approved flight maneuvers demonstrated in the type flight tests must be included, together with recommended entry speeds.

(f) *Flight load factor.* Each airplane flight manual must include the positive limit load factors made good by the airplane's structure, in terms of acceleration in *g*'s.

(g) *Flight crew.* If a flight crew of more than one is required to operate the airplane safely, each airplane flight manual must include the number and functions of the minimum flight crew.

(h) *Kinds of operation.* Each airplane flight manual must include the kind of operations (such as VFR, IFR, day, or night) in which the airplane may or may not be used and the meteorological conditions under which it may or may not be used. Any installed equipment that affects the operating limitations of the airplane must be listed and identified as to operational function.

[Revision note: Based on § 3.778]

§ 23.1545 Operating procedures.

Each airplane flight manual must include information concerning normal and emergency procedures and other pertinent information necessary to safe operation. Procedures and pertinent information relating to the use of the airspeeds prescribed in § 23.1529(b) for airplanes of more than 6,000 pounds must be included.

[Revision note: Based on § 3.779]

§ 23.1547 Performance information for airplanes with a maximum certificated weight of more than 6,000 pounds.

(a) Each airplane flight manual must include the following information:

(1) The stalling speed, V_{S_0} at maximum weight.

(2) The stalling speed, V_{S_1} at maximum weight and with landing gear and wing flaps retracted, and the effect upon this stalling speed of angles of bank up to 60 degrees.

(3) The takeoff distance determined in accordance with § 23.61, the airspeed at the 50-foot height, and, if pertinent, the airplane configuration.

(4) The landing distance determined in accordance with § 23.85, and, if pertinent, the airplane configuration.

(5) The steady rate of climb, determined in accordance with paragraphs (a), (b) (if appropriate), and (c) of § 23.73, the airspeed, power, and, if pertinent, the airplane configuration.

(b) Each airplane flight manual must contain the calculated approximate effect on takeoff distance (paragraph (a) (3) of this section), landing distance (paragraph (a) (4) of this section), and steady rate of climb (paragraph (a) (5) of this section), of variations in—

(1) Altitude from sea level to 8,000 feet; and

(2) Temperature at these altitudes from minus 60 degrees F. below standard to plus 40 degrees F. above standard.

(c) Each airplane flight manual must include the best climb speed or the minimum descent speed for multiengine airplanes with one engine inoperative.

(d) If landplane takeoff and landing distances are included in the airplane flight manual, it is not necessary, in complying with paragraph (a) (3) and (4) of this section, to make takeoff and landing distance tests for skiplane installations. A statement in the airplane flight manual of the approximate reduction in climb performance may be used instead of including complete new data for the skiplane configuration if—

(1) The landing gear is fixed in both landplane and skiplane configurations;

(2) The climb requirements are not critical; and

(3) The climb reduction in the skiplane configurations is small (30 to 50 feet per minute).

[Revision note: Combines §§ 3.780, 3.780–3(a) (1st sentence), and 3.780–3(b) (1st sentence)]

APPENDIX A—SIMPLIFIED DESIGN LOAD CRITERIA FOR CONVENTIONAL, SINGLE-ENGINE AIRPLANES OF 6,000 POUNDS OR LESS MAXIMUM WEIGHT

A23.1 *General.*

(a) The design load criteria in this Appendix are an approved equivalent of those in §§ 23.233 through 23.359 of this subchapter for the certification of conventional, single-engine airplanes of 6,000 pounds or less maximum weight.

(b) Unless otherwise stated, the nomenclature and symbols in this Appendix are the same as the corresponding nomenclature and symbols in Part 23.

[Revision note: Combines §§ 1.1 (less last sentence) and 3.1 (introductory paragraph)]

A23.3 *Special symbols used in this Appendix.*

n_1 = Airplane Positive Maneuvering Limit Load Factor.

n_2 = Airplane Negative Maneuvering Limit Load Factor.

n_3 = Airplane Positive 30 fps Gust Limit Load Factor at V_C.

n_4 = Airplane Negative 30 fps Gust Limit Load Factor at V_C.

n_{flap} = Airplane Positive Limit Load Factor With Flaps Fully Extended at V_F.

*$V_{F\,min}$ = Minimum Design Flap Speed = $12.5\sqrt{n_1 W/S}$

*$V_{A\,min}$ = Minimum Design Maneuvering Speed = $17.0\sqrt{n_1 W/S}$

*$V_{C\,min}$ = Minimum Design Cruising Speed = $19.5\sqrt{n_1 W/S}$

*$V_{D\,min}$ = Minimum Design Dive Speed = $27.3\sqrt{n_1 W/S}$

*Also see paragraph A23.7(e)(2) of this Appendix.

[Revision note: Based on § 3.1 (less introductory paragraph)]

A23.5 *Certification in more than one category.*

The criteria in this Appendix may be used for certification in the normal, utility, and acrobatic categories, or in any combination of these categories. If certification in more than one category is desired, the design category weights must be selected to make the term "n_1W" constant for all categories or greater for one desired category than for others. The wings and control surfaces (including wing flaps and tabs) need only be investigated for the maximum value of "n_1W", or for the category corresponding to the maximum design weight, where "n_1W" is constant. If the acrobatic category is selected, a special unsymmetrical flight load investigation in accordance with subparagraphs A23.9(c)(2) and A23.11(c)(2) of this Appendix must be completed. The wing, wing carrythrough, and the horizontal tail structures must be checked for this condition. The basic fuselage structure need only be investigated for the highest load factor design category selected. The local supporting structure for dead weight items need only be designed for the highest load factor imposed when the particular items are installed in the airplane. The engine mount, however, must be designed for a higher side load factor, if certification in the acrobatic category is desired, than that required for certification in the normal and utility categories. When designing for landing loads, the landing gear and the airplane as a whole need only be investigated for the category corresponding to the maximum design weight. These simplifications apply to single-engine aircraft of conventional types for which experience is available, and the Administrator may require additional investigations for aircraft with unusual design features.

[Revision note: Based on § 4.0]

A23.7 *Flight loads.*

(a) Each flight load may be considered independent of altitude and, except for the local supporting structure for dead weight items, only the maximum design weight conditions must be investigated.

(b) Table 1 and figures 3 and 4 of this Appendix must be used to determine values of n_1, n_2, n_3, and n_4, corresponding to the maximum design weights in the desired categories.

(c) Figures 1 and 2 of this Appendix must be used to determine values of n_2 and n_4 corresponding to the minimum flying weights in the desired categories, and, if these load factors are greater than the load factors at the design weight, the supporting structure for dead weight items must be substantiated for the resulting higher load factors.

(d) Each specified wing and tail loading is independent of the center of gravity range. The applicant, however, must select a c.g. range, and the basic fuselage structure must be investigated for the most adverse dead weight loading conditions for the c.g. range selected.

(e) The following loads and loading conditions are the minimums for which strength must be provided in the structure:

(1) *Airplane equilibrium.* Vertical wing loads may be found directly from vertical airplane loads by multiplying the airplane loads (as determined from paragraphs A23.9 (b) and (c) of this Appendix) by a factor of 1.05 for the positive flight conditions and 1.0 for the negative. The vertical wing load is the wing load vertical to the relative wind. All chordwise components of the vertical wing load must be taken into consideration.

(2) *Minimum design airspeeds.* The minimum design airspeeds may be chosen by the applicant except that they may not be less than the minimum speeds found by using figure 3 of this Appendix. In addition, $V_{C\,min}$ need not exceed values of $0.9v_H$ actually obtained at sea level for the lowest design weight category for which certification is desired. In computing these minimum design airspeeds, n_1 may not be less than 3.8

(3) *Flight load factor.* The limit flight load factors specified in Table 1 of this Appendix represent the acceleration component in terms of the gravitational constant, g, normal to the assumed longitudinal axis of the airplane, and equal in magnitude and opposite in direction to the airplane inertia load factor at the center of gravity.

[Revision note: Based on § 5.0 (less 3d sentence of paragraph 5.2)]

A23.9 *Flight conditions.*

(a) *General.* Each design condition in paragraphs (b) and (c) of this section must be used to assure sufficient strength for each condition of speed and load factor on or within the boundary of a V–n diagram for the airplane similar to the diagram in figure 4 of this Appendix. This diagram must also be used to determine the airplane structural operating limitations as specified in §§ 23.1403 through 23.1423 and 23.1443.

(b) *Symmetrical flight conditions.* The airplane must be designed for symmetrical flight conditions as follows:

(1) The airplane must be designed for at least the four basic flight conditions, "A",

"D", "E", and "G" as noted on the flight envelope of figure 4 of this Appendix. In addition, the following requirements apply:

(i) The design limit flight load factors corresponding to conditions "D" and "E" of figure 4 must be at least as great as those specified in Table 1 and figure 4 of this Appendix, and the design speed for these conditions must be at least equal to the value of V_D found from figure 3 of this Appendix.

(ii) For conditions "A" and "G" of figure 4, the load factors must correspond to those specified in Table 1 of this Appendix, and the design speeds must be computed using these load factors with the maximum static lift coefficient C_{N_A} determined by the applicant. However, in the absence of more precise computations, these latter conditions may be based on a value of $C_{N_A}=\pm 1.35$ and the design speed for condition "A" may be less than $V_{A\ min}$.

(iii) Conditions "C" and "F" of figure 4 need only be investigated when n_3W/S or n_4W/S are greater than n_1W/S or n_2W/S of this Appendix respectively.

(2) If flaps or other high lift devices intended for use at the relatively low airspeed of approach, landing, and takeoff, are installed, the airplane must be designed for the two flight conditions corresponding to the values of limit flap-down factors specified in Table 1 of this Appendix with the flaps fully extended at not less than the design flap speed $V_{F\ min}$ from figure 3 of this Appendix.

(c) *Unsymmetrical flight conditions.* Each affected structure must be designed for unsymmetrical loadings as follows:

(1) The aft fuselage-to-wing attachment must be designed for the critical vertical surface load determined in accordance with subparagraphs A23.11(c) (1) and (2) of this Appendix.

(2) The wing and wing carry-through structures must be designed for 100 percent of condition "A" loading on one side of the plane of symmetry and 70 percent on the opposite side for certification in the normal and utility categories, or 60 percent on the opposite side for certification in the acrobatic category.

(3) The wing and wing carry-through structures must be designed for the loads resulting from a combination of 75 percent of the positive maneuvering wing loading on both sides of the plane of symmetry and the maximum wing torsion resulting from aileron displacement. The effect of aileron displacement on wing torsion at V_C or V_A using the basic airfoil moment coefficient modified over the aileron portion of the span, must be computed as follows:

(i) $C_m=C_m+0.1\delta_u$ (up aileron side) wing basic airfoil.

(ii) $C_m=C_m-0.1\delta_d$ (down aileron side) wing basic airfoil, where δ_u is the up aileron deflection and δ_d is the down aileron deflection.

(4) Δ critical, which is the sum of $\delta_u+\delta_d$, must be computed as follows:

(i) Compute Δ_a and Δ_b from the formulas:

$$\Delta_a=\frac{V_A}{V_C}\times\Delta_a \text{ and}$$

$$\Delta_b=0.5\frac{V_A}{V_D}\times\Delta_a$$

where Δ_a=the maximum total deflection (sum of both aileron deflections) at V_A with V_A, V_C, and V_D described in subparagraph (2) of § 23.7(e) of this Appendix.

(ii) Compute K from the formula:

$$K=\frac{(C_m-0.01\delta_b)V_D^2}{(C_m-0.01\delta_a)V_C^2}$$

where δ_a is the down aileron deflection corresponding to Δ_a, and δ_b is the down aileron deflection corresponding to Δ_b as computed in step (1).

(iii) If K is less than 1.0, Δ_a is Δ critical and must be used to determine δ_u and δ_d. In this case, V_C is the critical speed which must be used in computing the wing torsion loads over the aileron span.

(iv) If K is equal to or greater than 1.0, Δ_b is Δ critical and must be used to determine δ_u and δ_d. In this case, V_D is the critical speed which must be used in computing the wing torsion loads over the aileron span.

(d) *Supplementary conditions; rear lift truss; engine torque; side load on engine mount.* Each of the following supplementary conditions must be investigated:

(1) In designing the rear lift truss, the special condition specified in § 23.285 may be investigated instead of condition "G" of figure 4 of this Appendix. If this is done, and if certification in more than one category is desired, the value of W/S used in the formula appearing in § 23.285 must be that for the category corresponding to the maximum gross weight.

(2) Each engine mount and its supporting structures must be designed for the maximum limit torque corresponding to METO power and propeller speed acting simultaneously with the limit loads resulting from the maximum positive maneuvering flight load factor n_1. The limit torque must be obtained by multiplying the mean torque by a factor of 1.33 for engines with five or more cylinders. For 4, 3, and 2 cylinder engines, the factor must be 2, 3, and 4, respectively.

(3) Each engine mount and its supporting structure must be designed for the loads resulting from a lateral limit load factor of not less than 1.47 for the normal and utility categories, or 2.0 for the acrobatic category.

[Revision note: Based on § 6.0]

A23.11 *Control surface loads.*

(a) *General.* Each control surface load must be determined using the criteria of paragraph (b) of this section and must lie within the simplified loadings of paragraph (c) of this section.

(b) *Pilot effort.* In each control surface loading condition described in paragraphs (c) through (e) of this section, the airloads on the movable surfaces and the corresponding deflections need not exceed those which could be obtained in flight by employing the maximum pilot control forces specified in the table in § 23.303. If the surface loads are limited by maximum pilot effort, the tabs must either be considered to be deflected to their maximum travel in the direction which would assist the pilot or the deflection must correspond to the maximum degree of "out of trim" expected at the speed for the condition under consideration. The tab load, however, need not exceed the value specified in Table 2 of this Appendix.

(c) *Surface loading conditions.* Each surface loading condition must be investigated as follows:

(1) Simplified limit surface loadings and distributions for the horizontal tail, vertical tail, aileron, wing flaps, and trim tabs are specified in Table 2 and figures 5 and 6 of this Appendix. If more than one distribution is given, each distribution must be investigated.

(2) If certification in the acrobatic category is desired, the horizontal tail must be investigated for an unsymmetrical load of 100 percent W on one side of the airplane centerline and 50 percent on the other side of the airplane centerline.

(d) *Outboard fins.* Outboard fins must conform to the requirements of § 23.335.

(e) *Special devices.* Special devices must conform to the requirements of § 23.351.

[Revision note: Based on § 7.0]

A23.13 *Control system loads.*

(a) *Primary flight controls and systems.* Each primary flight control and system must be designed as follows:

(1) The flight control system and its supporting structure must be designed for loads corresponding to 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in A23.11 of this Appendix. In addition—

(i) The system limit loads need not exceed those that could be produced by the pilot and automatic devices operating the controls; and

(ii) The design must provide a rugged system for service use, including jamming, ground gusts, taxiing downwind, control inertia, and friction.

(2) Acceptable maximum and minimum pilot loads for elevator, aileron, and rudder controls are shown in the table in § 23.303. These pilots loads must be assumed to act at the appropriate control grips or pads as they would under flight conditions, and to be reacted at the attachments of the control system to the control surface horn.

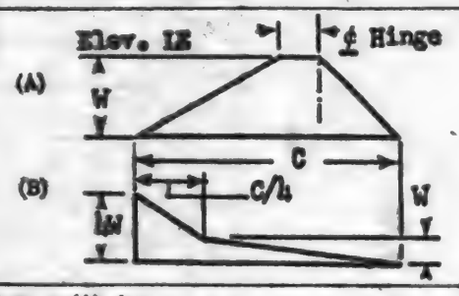
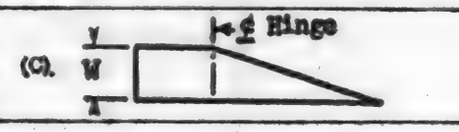
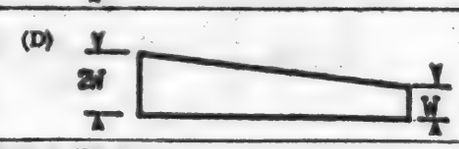
(b) *Dual controls.* If there are dual controls, the systems must be designed for pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with paragraph (a) of this section, except that individual pilot loads may not be less than the minimum loads shown in the table in § 23.303.

TABLE 1—LIMIT FLIGHT LOAD FACTORS

LIMIT FLIGHT LOAD FACTORS			Normal category	Utility category	Acrobatic category
FLIGHT Load Factors	Flaps Up	n_1	3.8	4.4	6.0
		n_2	$-0.5n_1$		
		n_3	Find n_3 from Fig. 1		
		n_4	Find n_4 from Fig. 2		
	Flaps Down	n_{flap}	$0.5n_1$		
		n_{flap}	Zero*		

*Vertical wing load may be assumed equal to zero and only the flap part of the wing need be checked for this condition.

TABLE 2—AVERAGE LIMIT CONTROL SURFACE LOADING

AVERAGE LIMIT CONTROL SURFACE LOADING			
SURFACE	DIRECTION OF LOADING	MAGNITUDE OF LOADING	CHORDWISE DISTRIBUTION
HORIZONTAL TAIL I	a) Up and Down	Figure 5 Curve (2)	
	b) Unsymmetrical loading (Up and Down)	100% $\bar{w}$ on one side airplane ℄ 65% $\bar{w}$ on other side of airplane ℄ for the normal and utility categories. For the acrobatic category see A23.11(c).	
VERTICAL TAIL II	a) Right and Left	Figure 5 Curve (1)	Same as (A) above
	b) Right and Left	Figure 5 Curve (1)	Same as (B) above
AILERON III	a) Up and Down	Figure 6 Curve (5)	
WING FLAP IV	a) Up	Figure 6 Curve (4)	
	b) Down	.25 x Up Load (a)	
TRIM TAB V	a) Up and Down	Figure 6 Curve (3)	Same as (D) above

The surface loadings I, II, III, and V above are based on speeds $V_{A\ min}$ and $V_{C\ min}$. The loading of IV is based on $V_{f\ min}$. If values of speeds greater than these minimums are selected for design the appropriate surface loadings must be multiplied by the ratio $\left[\frac{V_{sel}}{V_{min}}\right]^2$.

For conditions I, II, III and V the multiplying factor used must be the higher of $\left[\frac{V_{A\ sel}}{V_{A\ min}}\right]^2$ or $\left[\frac{V_{C\ sel}}{V_{C\ min}}\right]^2$.

FIGURE 1 – CHART FOR FINDING n_3 FACTOR AT SPEED V_C

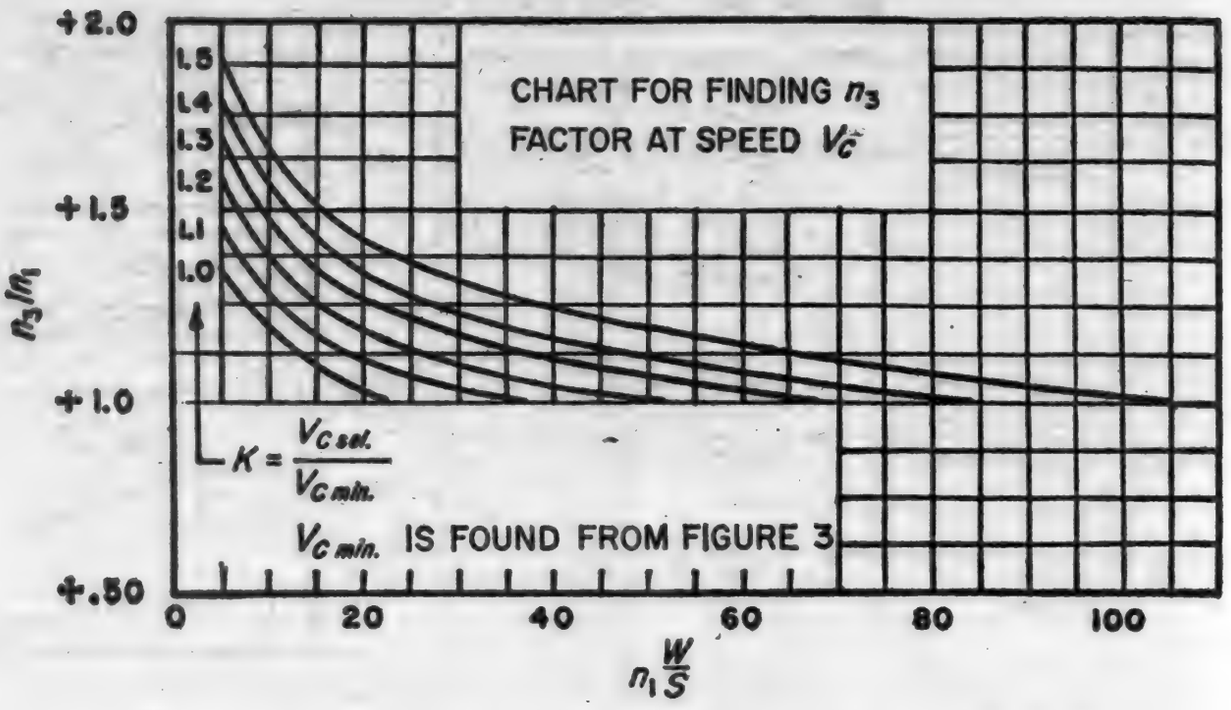


FIGURE 2 – CHART FOR FINDING n_4 FACTOR AT SPEED V_C

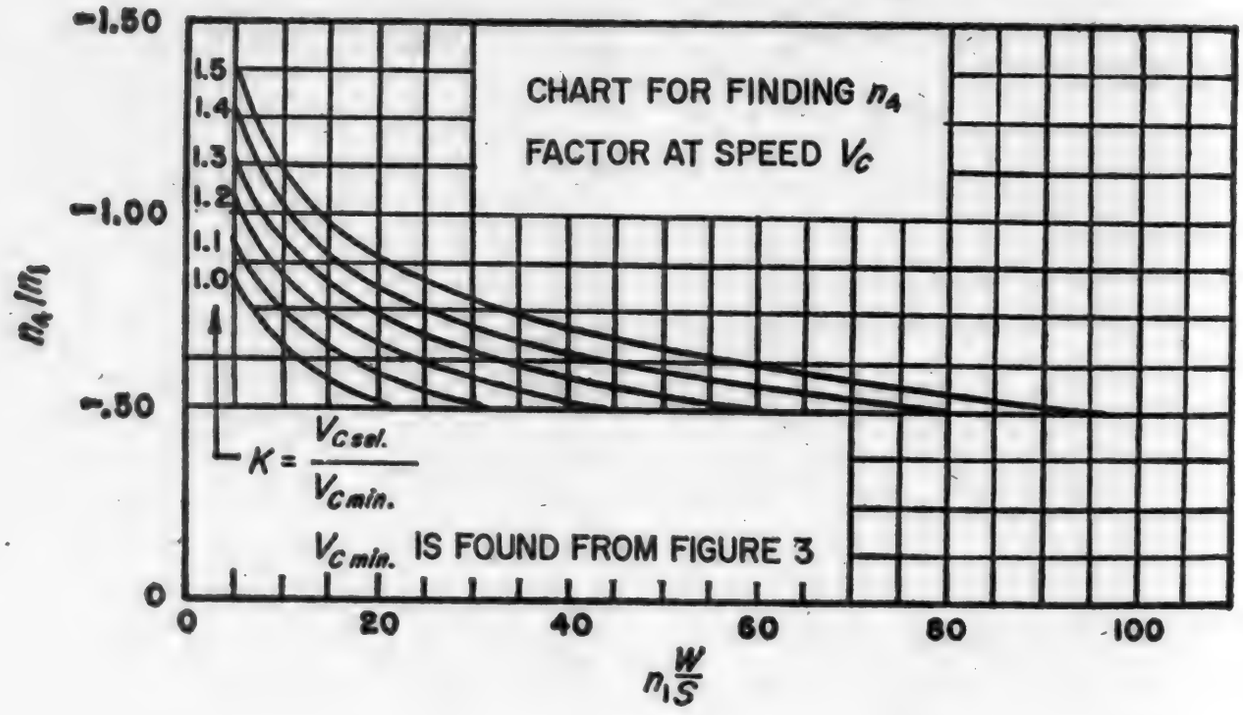


FIGURE 3 - MINIMUM DESIGN AIRSPEEDS

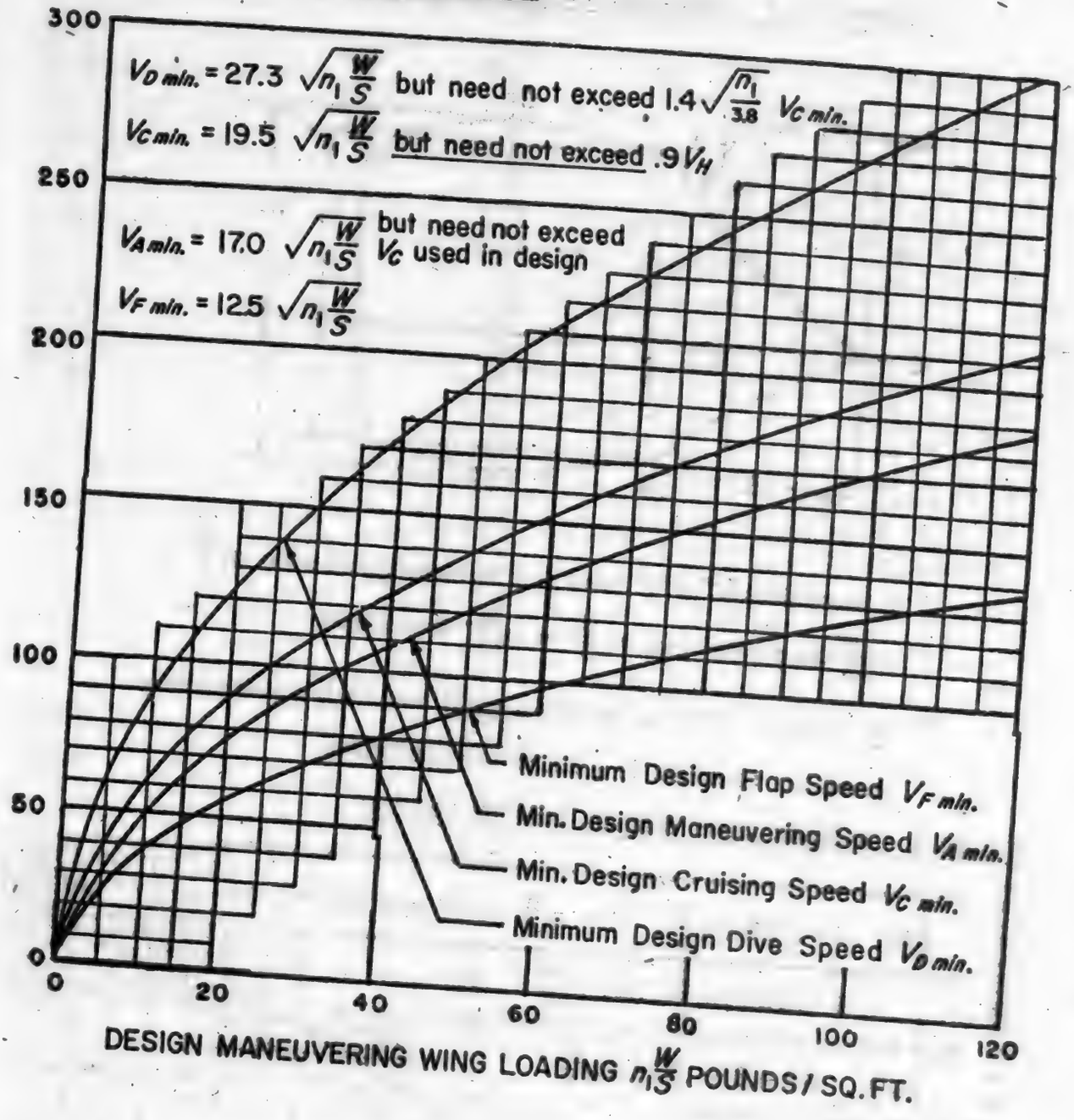
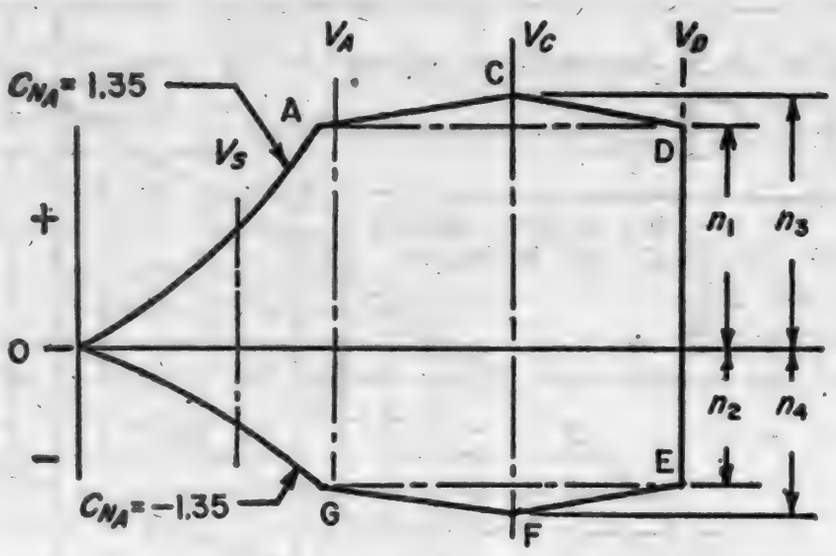


FIGURE 4 – V–n DIAGRAM (FLIGHT ENVELOPE)



1. Conditions "C" or "F" need only be investigated when $n_3\frac{W}{S}$ or $n_4\frac{W}{S}$ is greater than $n_1\frac{W}{S}$ or $n_2\frac{W}{S}$, respectively.

2. Condition "G" need not investigated when the supplementary condition specified in § 23.285 is investigated.

FIGURE 5 - AVERAGE LIMIT CONTROL SURFACE LOADING

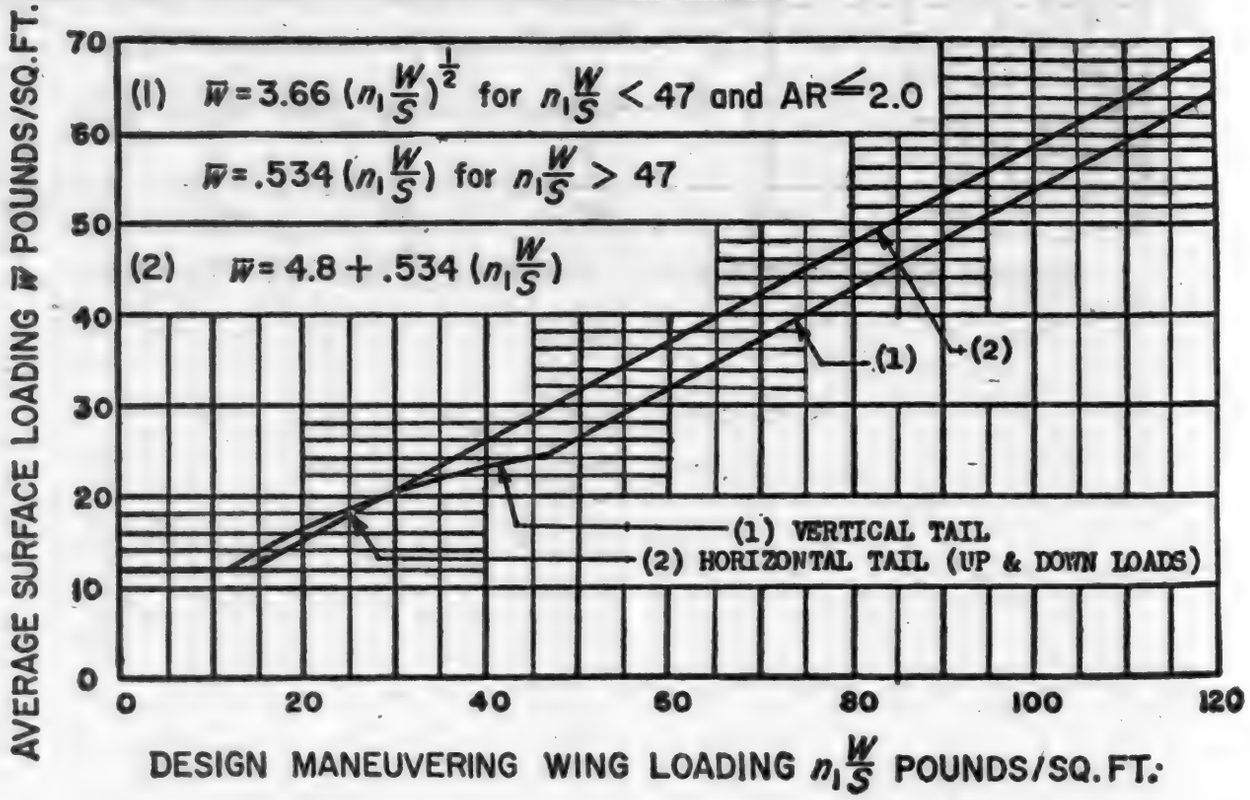
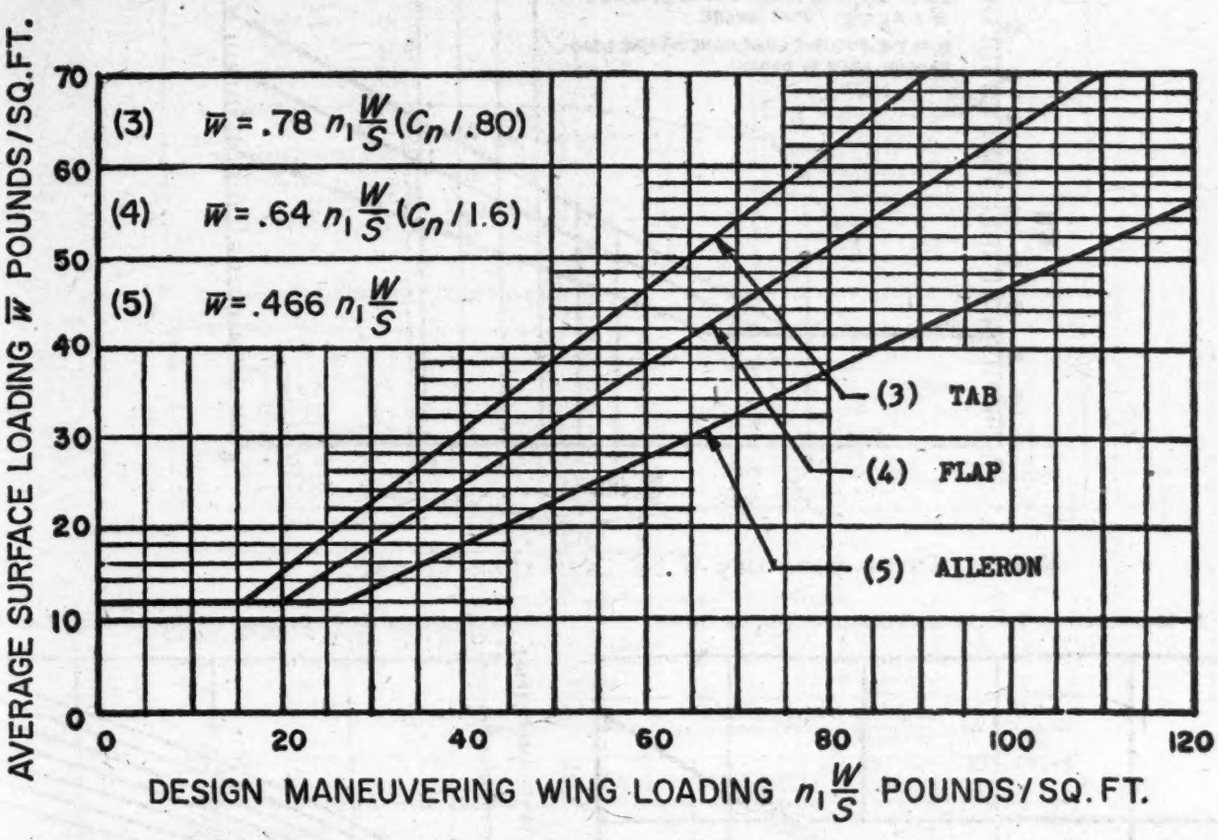


FIGURE 6 - AVERAGE LIMIT CONTROL SURFACE LOADING



APPENDIX B—CONTROL SURFACE LOADINGS

B23.1 *General.*

(a) If allowed by the specific requirements in this part, the values of control surface loading in this appendix may be used to determine the detailed rational requirements of §§ 23.303 through 23.351 unless the Administrator finds that these values result in unrealistic loads.

(b) For a seaplane version of a landplane, the landplane wing loadings may be used to determine the limit maneuvering control surface loadings (in accordance with B23.11 and figure 1 of Appendix B) if—

(1) The power of the seaplane engine(s) does not exceed the power of the landplane engine(s);

(2) The placard maneuver speed of the seaplane does not exceed the placard maneuver speed of the landplane;

(3) The maximum certificated weight of the seaplane does not exceed the maximum certificated weight of the landplane by more than 10 percent;

(4) The landplane service experience does not show any serious control-surface load problem; and

(5) The landplane service experience is of sufficient scope to ascertain with reasonable accuracy that no serious control-surface load problem will develop on the seaplane.

B23.11 *Control surface loads.*

Acceptable values of limit average maneuvering control-surface loadings may be obtained from figure 1 of this Appendix in accordance with the following:

(a) For horizontal tail surfaces—

(1) With the conditions in § 23.317(a), obtain W as a function of W/S and surface deflection, using—

(i) Curve C of figure 1 for a deflection of 10° or less;

(ii) Curve B of figure 1 for a deflection or 20°;

(iii) Curve A for a deflection of 30° or more;

(iv) Interpolation for all other deflections; and

(v) The distribution of figure 7; and

(2) With the conditions in § 23.317(b), obtain W from curve B of figure (1) using the distribution of figure 7. (b) For vertical tail surfaces—

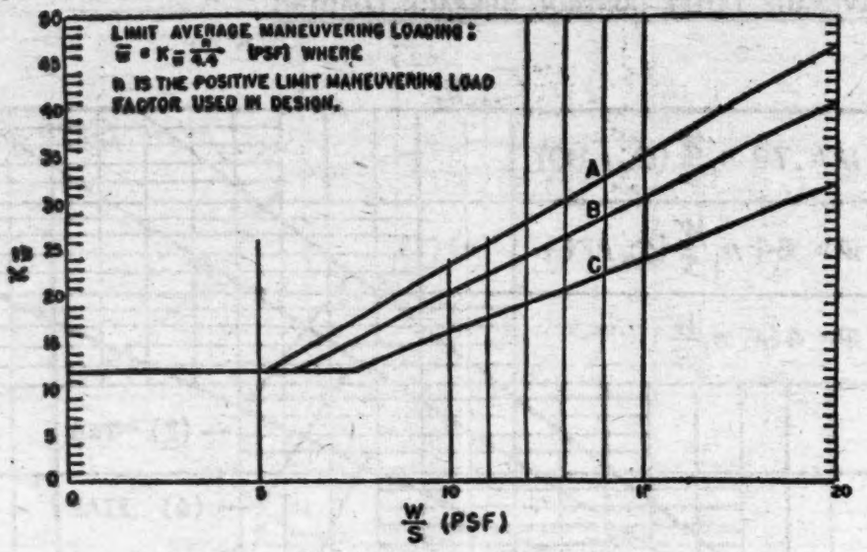
(1) With the conditions in § 23.331(a)(1), obtain W as a function of W/S and surface deflection using the same requirements as used in subdivisions (a)(1)(i) through (a)(1)(v);

(ii) With the conditions in § 23.331(a)(2), obtain W from Curve C, using the distribution of figure 6; and

(iii) With the conditions in § 23.331(a)(3), obtain W from Curve A, using the distribution of figure 8.

(c) For ailerons, obtain W from Curve B, acting in both the up and down directions, using the distribution of figure 9.

FIGURE 1—LIMIT AVERAGE MANEUVERING CONTROL SURFACE LOADING



Note: In no case may $\bar{w}$ be less than 12 psf.

FIGURE 2—MANEUVERING TAIL LOAD INCREMENT (UP OR DOWN)

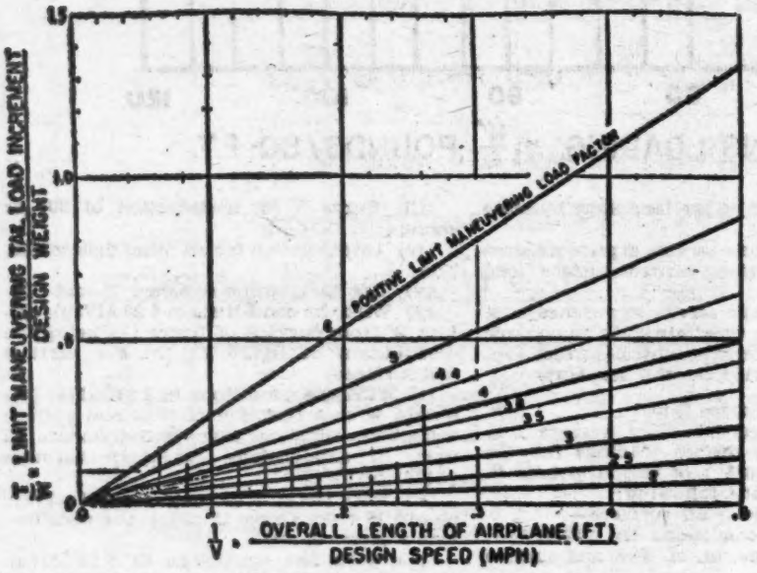

$\frac{\text{LIMIT MANEUVERING TAIL LOAD INCREMENT}}{\text{DESIGN WEIGHT}}$
POSITIVE LIMIT MANEUVERING LOAD FACTOR
$\frac{1}{V} = \frac{\text{OVERALL LENGTH OF AIRPLANE (FT)}}{\text{DESIGN SPEED (MPH)}}$

FIGURE 3—DOWN GUST LOADING ON HORIZONTAL TAIL SURFACE

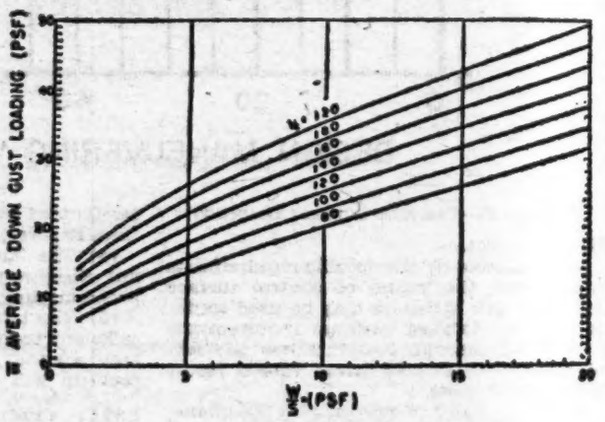


FIGURE 4—UP GUST LOADING ON HORIZONTAL TAIL SURFACE

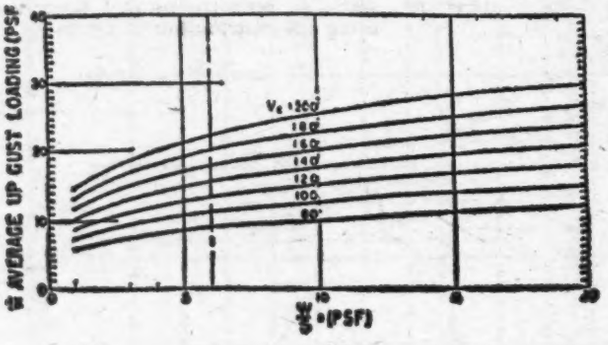


FIGURE 5—GUST LOADING ON VERTICAL TAIL SURFACE

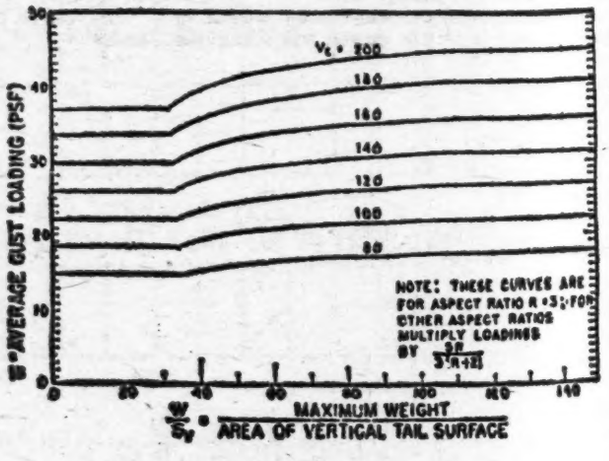

$\bar{w}$ AVERAGE GUST LOADING (PSF)
V_e = 200
180
160
140
120
100
80
NOTE: THESE CURVES ARE FOR ASPECT RATIO R = 3; FOR OTHER ASPECT RATIOS MULTIPLY LOADINGS BY $\frac{2R}{3(R+2)}$
$\frac{W}{S_v}$ = $\frac{\text{MAXIMUM WEIGHT}}{\text{AREA OF VERTICAL TAIL SURFACE}}$

FIGURE 6—TAIL SURFACE LOAD DISTRIBUTION

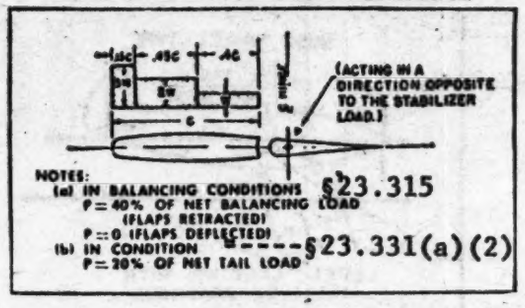

(ACTING IN A DIRECTION OPPOSITE TO THE STABILIZER LOAD.)
NOTES:
(a) IN BALANCING CONDITIONS P = 40% OF NET BALANCING LOAD (FLAPS RETRACTED) P = 0 (FLAPS DEFLECTED)
(b) IN CONDITION P = 20% OF NET TAIL LOAD
§23.315
§23.331(a)(2)

FIGURE 7—TAIL SURFACE LOAD DISTRIBUTION

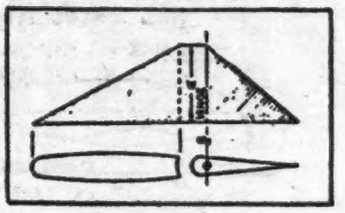


FIGURE 8—TAIL SURFACE LOAD DISTRIBUTION

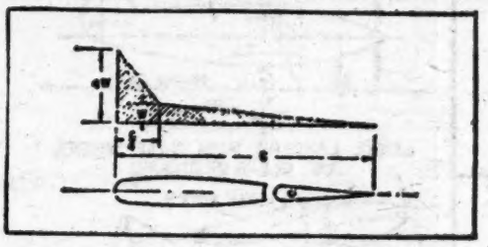
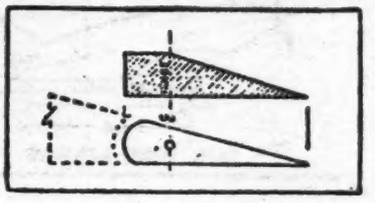


FIGURE 9—AILERON LOAD DISTRIBUTION



APPENDIX C—BASIC LANDING CONDITIONS

C23.1 *Basic landing conditions.*

Condition	Tail wheel type		Nose wheel type		
	Level landing	Tail-down landing	Level landing with inclined reactions	Level landing with nose wheel just clear of ground	Tail-down landing
Reference section	23.385(a)(1)	23.387(a)(1)	23.385(a)(2)(i)	23.385(a)(2)(ii)	23.387(a)(2) and (b)
Vertical component at c. g.	nW	nW	nW	nW	nW
Fore and aft component at c. g.	KnW	0	KnW	KnW	0
Lateral component in either direction at c. g.	0	0	0	0	0
Shock absorber extension (hydraulic shock absorber)	Note (2)	Note (2)	Note (2)	Note (2)	Note (2)
Shock absorber deflection (rubber or spring shock absorber)	100% Static	100% Static	100% Static	100% Static	100% Static
Tire deflection					
Main wheel loads (both wheels) V_r	$(n-L)W$	$(n-L)Wb/d$	$(n-L)Wa'/d'$	$(n-L)W$	$(n-L)W$
Main wheel loads (both wheels) D_r	KnW	0	$KnWa'/d'$	KnW	0
Tail (nose) wheel loads V_f	0	$(n-L)Wa/d$	$(n-L)Wb'/d'$	0	0
Tail (nose) wheel loads D_f	0	0	$KnWb'/d'$	0	0
Notes	(1), (3) and (4)	(4)	(1)	(1), (3), and (4)	(3) and (4)

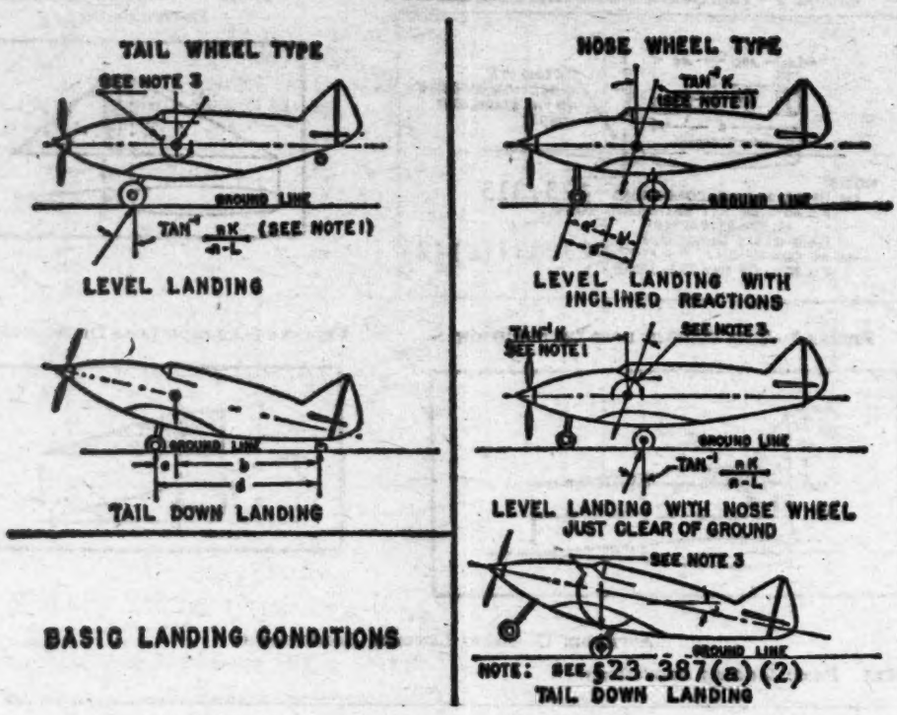
NOTE (1). K may be determined as follows: $K=0.25$ for $W=3{,}000$ pounds or less; $K=0.33$ for $W=6{,}000$ pounds or greater, with linear variation of K between these weights.

NOTE (2). For the purpose of design, the maximum load factor is assumed to occur throughout the shock absorber stroke from 25 percent deflection to 100 percent deflection unless otherwise shown and the load factor must be used with whatever shock absorber extension is most critical for each element of the landing gear.

NOTE (3). Unbalanced moments must be balanced by a rational or conservative method.

NOTE (4). L is defined in § 23.611(b).

FIGURE 1.



BASIC LANDING CONDITIONS

APPENDIX D—WHEEL SPIN-UP LOADS

D23.1 *Wheel spin-up loads.*

(a) The following method for determining wheel spin-up loads for landing conditions is based on NACA T.N. 863. However, the drag component used for design may not be less than the drag load prescribed in § 23.385(b).

$$F_{H\,max}=\frac{1}{r_e}\sqrt{\frac{2I_w(V_H-V_e)nF_{V\,max}}{t_z}}$$

where—

$F_{H\,max}$ = maximum rearward horizontal force acting on the wheel (in pounds);

r_e = effective rolling radius of wheel under impact based on recommended operating tire pressure (which may be assumed to be equal to the rolling radius under a static load of n_jW_e) in feet;

I_w = rotational mass moment of inertia of rolling assembly (in slug feet);

V_H = linear velocity of airplane parallel to ground at instant of contact (assumed to be 1.2 V_{S_0}, in feet per second);

V_e = peripheral speed of tire, if pre-rotation is used (in feet per second) (there must be a positive means of pre-rotation before pre-rotation may be considered);

n = effective coefficient of friction (0.80 may be used);

$F_{V\,max}$ = maximum vertical force on wheel (pounds) = n_jW_e, where W_e and n_j are defined in §§ 23.611 and 23.613;

t_z = time interval between ground contract and attainment of maximum vertical force on wheel (seconds). (However, if the value of $F_{V\,max}$ from the above equation exceeds 0.8 $F_{V\,max}$, the later value must be used for $F_{H\,max}$.)

(b) This equation assumes a linear variation of load factor with time until the peak load is reached and under this assumption, the equation determines the drag force at the time that the wheel peripheral velocity at radius r_e equals the airplane velocity. Most shock absorbers do not exactly follow a linear variation of load factor with time. Therefore, rational or conservative allowances must be made to compensate for these variations. On most landing gears, the time for wheel spin-up will be less than the time required to develop maximum vertical load factor for the specified rate of descent and forward velocity. For exceptionally large wheels, a wheel peripheral velocity equal to the ground speed may not have been attained at time of maximum vertical gear load. However, as stated above, the drag spin-up load need not exceed 0.8 of the maximum vertical loads.

[F.R. Doc. 64-3688; Filed, Apr. 13, 1964; 8:50 a.m.]